U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-260 309

SURVEY OF INTERSTATE POLLUTION OF THE BEAR RIVER AND TRIBUTARIES, IDAHO-UTAH, 1972

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

April 1963

217007

PB 260 309

Survey
of
Interstate Pollution
# of the
Bear River and Tributaries

Idaho – Utah
1962

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service

BIBLIOGRAPHIC DATA SHEET

1. Report No.

2.

3. Recipient's Accession No.
PB-260 309

4. Title and Subtitle
Survey of Interstate Pollution of the Bear River and Tributaries, Idaho-Utah, 1972

5. Report Date
Apr 63

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Div. of Water Supply and Pollution Control

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

Findings of a field survey of the interstate waters of the Bear River, including the Cub River and Worm Creek, in Utah and Idaho, which was conducted in August and November of 1962 are reported. The primary objective was to obtain sufficient additional information on the characteristics of this system of streams and the wastes discharged to it to permit development of a plan for pollution abatement. This report deals with hydrology, waste sources, and stream conditions, including chemical characteristics, bacteriological quality, and stream biology.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms

Bear River
*Water pollution sampling
Cub River
Worm Creek
Utah
Idaho
Waste disposal
Stream flow
Bacteria
Chemical analysis
Aquatic ecosystems
Hydrology
*Water quality data

17c. COSATI Field/Group 13B

18. Availability Statement

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
121

22. Price

EPA Region VIII LIBRARY
Denver, Colorado

Survey of
Interstate Pollution
# of the
Bear River and Tributaries
Idaho-Utah
1962

U. S. Department of Health, Education, and Welfare
Public Health Service
Division of Water Supply and Pollution Control
R. A. Taft Sanitary Engineering Center
Cincinnati, Ohio

April 1963

TABLE OF CONTENTS

	Page
INTRODUCTION	1
HYDROLOGY	2
WASTE SOURCES	9
STREAM CONDITIONS	20
Chemical Characteristics	20
Bacteriological Quality	31
Stream Biology	42
SUMMARY OF EXISTING POLLUTION	59
PLAN FOR POLLUTION ABATEMENT	62
CONCLUSIONS	78

APPENDICES

APPENDIX "A" - Amended Order, Utah State Water Pollution Control Board	A-1
APPENDIX "B" - River Basin Analysis to Determine Discharge Requirements	B-1
APPENDIX "C" - Time of Passage and Deoxygenation Rate Data	C-1

LIST OF TABLES

Table No. Page

1 Average Waste Discharge Characteristics 12

2 Average Stream Water Quality Conditions - August 1962 26

3 Average Stream Water Quality Conditions - November 1962 32

4 Benthos Data - Cub River 1962 . . . . Following 46

5 Benthos Data - Upper Worm Creek and Cub West Canal 1962 . . . . Following 48

6 Benthos Data - Cub Canal, Cub East Canal, and Lower Worm Creek 1962 . . . . Following 50

7 Benthos Data - Bear River 1962 . . . . Following 52

8 Maximum Permissible Waste Discharges - Bear River System 66

9 Observed versus Permissible Waste Discharges, Lbs.BOD/Day 69

LIST OF FIGURES

Figure No. Following Page

1 Bear River and Tributaries 2

2 Cub River Flow and Diversions - 1948 4

3 Cub River Bacterial Densities - August 1962 36

4 Bear River Bacterial Densities - August 1962 38

5 Cub River Bacterial Densities - November 1962 40

6 Bear River Bacterial Densities - November 1962 . . . 42

LIST OF FIGURES (continued)

Figure No.		Following Page
7	Benthos Data - Bear River System 1962	46
8	Benthos Data - Bear River System 1962	48
9	Sludgeworms in Worm Creek at W-4.4 - November 3, 1962, 2:15 PM . . .	52
10	Sludge in Worm Creek at W-4.4 - November 3, 1962, 2:20 PM . . .	52
11	Foam from Calcium Carbonate Waste Pond on Worm Creek - November 3, 1962, 3:00 PM . . .	52
12	Cub River near Franklin, Minimum Year of Record (1941)	74
B-1	Schematic Flow Diagram, Bear River System . . .	B-3

SURVEY PERSONNEL

The following Public Health Service personnel participated in one or both of the two segments of the 1962 survey described in this report.

Project Engineer:	R. L. O'Connell, Sr. San. Engr.
Field Activities:	S. D. Shearer, S. E.
	R. M. Clark, A.S.E.
	J. D. Russell, A.S.E.
	B. D. Clark, A.S.E.
	J. K. Carswell, A.S.E.
	T. A. Wandstrat, Phys. Sci. Aide
	R. C. Rivenes, Engrg. Aide
	R. M. McCullough, Gen. Mechanic
Biology:	K. M. Mackenthun, Biologist
	N. A. Thomas, Biologist
Bacteriology:	E. E. Geldreich, Bacteriologist
	C. B. Huff, Bacteriologist
	W. J. Spangler, Bacteriologist
	B. L. Smith, Phys. Sci. Aide
Chemistry:	C. R. Hirth, Chemist
	M. W. Lammering, S.A.S.E.
	J. W. Mandia, Chemist
	D. C. Sawtelle, Chemist
	A. E. McSorley, Phys. Sci. Aide
	R. E. Loebker, Phys. Sci. Aide
Industrial Wastes:	J. M. Fairall, P.H.Engr.

ACKNOWLEDGMENT

Assistance and advice were rendered by Mr. W. N. Jibson, U. S. Geological Survey, and Dr. W. F. Sigler, Utah State University. Many others at the University were most helpful in providing laboratory space and other facilities required to accomplish this field survey. Staff members of the Health Departments of the States of Utah and Idaho were most cooperative as were the industries concerned in making necessary arrangements for sample collection and flow measurements. Dr. E. C. Tsivoglou, H. H. Black, and H. F. Clark provided technical guidance throughout all phases of the study.

INTRODUCTION

It has been established at the first two sessions of the Conference on Pollution of Interstate Waters of the Bear River held in October 1958 and July 1960 that pollution of interstate waters subject to abatement under the Federal Water Pollution Control Act was occurring in the Bear River and its tributaries, the Cub River and Worm Creek. Field studies of stream conditions which, in part, formed the basis for this finding were conducted by the Public Health Service in 1955. Surveys have also been conducted by the States of Utah and Idaho, and an additional Public Health Service survey was performed in November of 1960.

This report describes the findings of a field survey of these streams which was conducted in two parts in August and November of 1962. The primary objective of this survey was to obtain sufficient additional information on the characteristics of this system of streams and the wastes discharged to it to permit development of a plan for pollution abatement. The survey was also designed to show present levels of pollution during the two critical periods of the year, i.e., the irrigation and bean canning season in August, and the sugar beet processing and sauerkraut canning season in November. Knowledge was also desired of the extent of improvements effected, if any, in waste discharge practices since the prior field surveys were carried out.

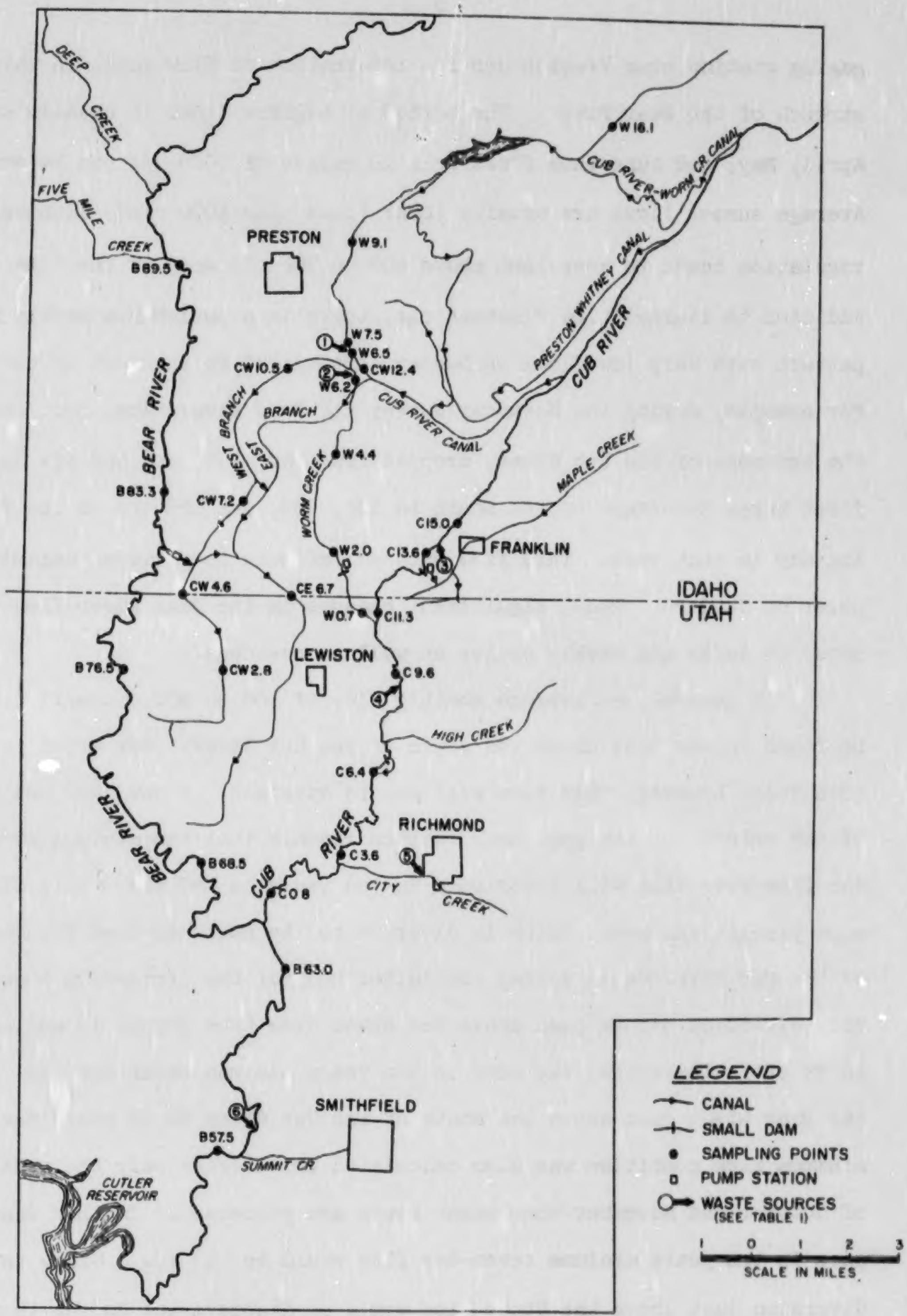
HYDROLOGY

Stream flows in the Bear River and its tributaries in the area studied (see Figure 1) are highly regulated for irrigation and power production uses. Great variations in flow occur seasonally due to irrigation usage, while power production causes diurnal changes in flow. A large portion of the Cache Valley lowlands is devoted to irrigated agriculture, and utilization of available water resources for this purpose has become quite extensive. As a result, the valley is interlaced with canals which transport water from reservoirs and stream diversion points to agricultural lands where it is applied. A system of ditches drain these areas of excess water and discharge to natural drainage courses. The irrigation season extends from the latter part of May to September.

Ground water is plentiful in this area and in many places can be obtained at shallow depths. Artesian free-flowing wells are numerous in the valley.

BEAR RIVER

The flow in the Bear River as it crosses the State line is regulated by the Oneida Dam located about 15 miles northeast of Preston. Release of stored water for power production greatly increases in the evening resulting in high downstream flows at night and much lower flows during daylight hours. Records of the U. S. Geological Survey stream


DEEP CREEK
FIVE MILE CREEK
PRESTON
B89.5
W9.1
W16.1
CUB RIVER-WORM CR CANAL
PRESTON WHITNEY CANAL
CUB RIVER
BEAR RIVER
W7.5
W6.5
CW10.5
CW12.4
W6.2
WEST BRANCH
EAST BRANCH
CUB RIVER CANAL
W4.4
MAPLE CREEK
WORM CREEK
B83.3
CW7.2
C15.0
C13.6
FRANKLIN
W2.0
CW4.6
CE6.7
IDAHO
UTAH
W0.7
C11.3
LEWISTON
B76.5
CW2.8
C9.6
HIGH CREEK
C6.4
RICHMOND
BEAR RIVER
CUB RIVER
C3.6
B68.5
C0.8
CITY CREEK
B63.0
SMITHFIELD
B57.5
SUMMIT CR
CUTLER RESERVOIR
LEGEND
CANAL
SMALL DAM
SAMPLING POINTS
PUMP STATION
WASTE SOURCES (SEE TABLE I)
1 0 1 2 3
SCALE IN MILES
①
②
③
④
⑤
⑥

BEAR RIVER AND TRIBUTARIES

FIGURE I

gaging station near Preston provide information on flow rates in this stretch of the Bear River. The period of highest flows is usually during April, May, and June when flows well in excess of 1000 cfs can be expected. Average summer flows are usually lower (less than 1000 cfs), although regulation tends to keep them above 400 to 500 cfs most of the time. In addition to diurnal flow fluctuations, there is a noticeable weekly flow pattern with very low flows on Sunday as compared to the rest of the week. For example, during the November survey the Bear River flow, just above the entrance of the Cub River, dropped from 540, 490, and 560 cfs on the first three Saturdays of the month to 180, 280, and 120 cfs on the following day in each case. This flow pattern reflects the lowered demand for power on Sundays. Thus, significant changes in the Bear River flow rate occur in daily and weekly cycles as well as seasonally.

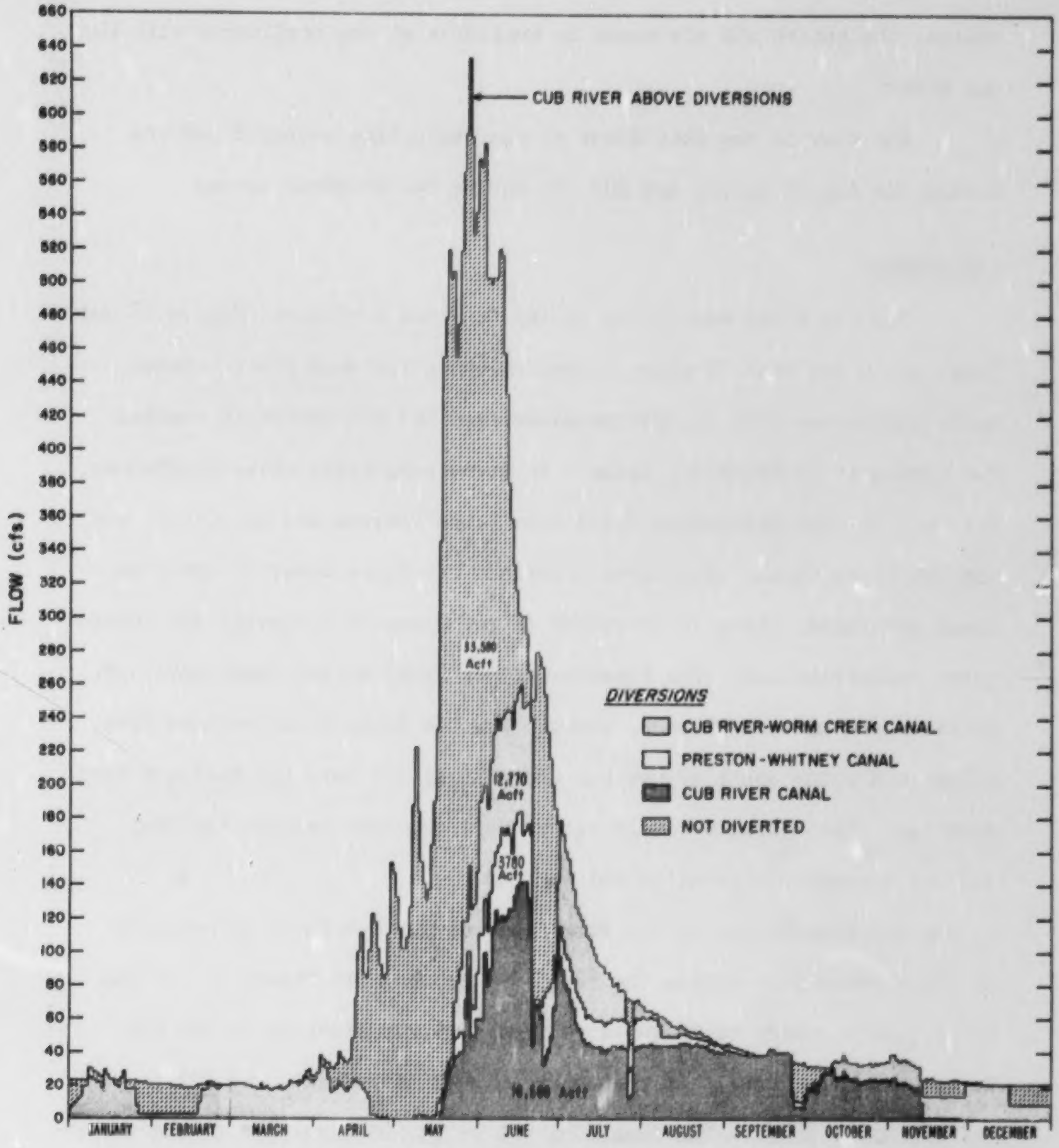
In general, an average monthly flow of 400 to 500 cfs will usually be found in the Bear above the mouth of the Cub River. For brief periods each year, however, this flow will not be attained. A low flow analysis of the record for the gage near Preston reveals that the minimum seven-day flow rate that will occur once in ten years is 140 cfs. This flow must provide the water which is diverted to the East and West Branches of the Cub River Canal during the latter half of the irrigation season. This diversion occurs just above the State line (see Figure 1) and amounts to 75 cfs. Therefore, the once in ten years minimum seven-day flow in the Bear River just above the mouth of the Cub River is 65 cfs. The same minimum flow condition was also calculated considering only the months of October and November when sugar beets are processed. In this case the once in ten years minimum seven-day flow would be 200 cfs. Since the diversion just above the State line would be discontinued during these months, the entire 200 cfs would be available at the confluence with the Cub River.

The flow in the Bear River at the State line averaged 508 cfs during the August survey and 390 cfs during the November survey.

CUB RIVER

The Cub River enters the valley from the northeast (Figure 1) and flows south for some 35 miles before entering the Bear River. Three major diversions take irrigation water from the Cub before it reaches the community of Franklin, Idaho. In downstream order these diversions are into the Cub River-Worm Creek Canal, the Preston Whitney Canal, and the Cub River Canal. The first transfers Cub River water to the Worm Creek watershed, where it is stored in the Glendale reservoir for subsequent redistribution. The Preston-Whitney Canal serves lands north of Franklin and east of Preston, Idaho. The Cub River Canal extends five miles to a point south of Preston where it splits into the East and West Branches. These branch canals serve the large area between the Bear and Cub Rivers both in Idaho and in Utah.

The disposition of the total flow of the Cub River as measured at the Preston gage during the year 1948 is shown in Figure 2. Of the total year's runoff of 66,700 acre-feet, 19% was diverted to the Cub River-Worm Creek Canal, 6% to the Preston-Whitney Canal, and 25% to the Cub River Canal. The remaining 50% or 33,600 acre-feet flowed to the Bear River. Almost all of this undiverted flow occurred during the months of April, May, and June. During the remaining nine months



CUB RIVER FLOW AND DIVERSIONS - 1948

FIGURE 2

of the year essentially the entire flow of the Cub River is diverted for irrigation uses.

Just downstream from Franklin, Idaho, another much smaller diversion from the Cub occurs. At this point there is a checkboard dam across the stream. During the irrigation season the checkboards are in place and water is pumped from the river for irrigation in Idaho and Utah. At many times during the irrigation season, all of the available flow in the Cub River is diverted and the stream bed is dry below this point to the confluence with Worm Creek in Utah. The average flow in this stretch of the Cub River during irrigation season is estimated to be 2 cfs.

From the confluence of Worm Creek just below the State line to where it enters the Bear River, the Cub River is fed by several small streams which originate on the mountain slopes on the east side of the valley. These tributaries have all been impounded, however, and all of their flow is diverted during the irrigation season. Seven miles above its mouth the Cub is again impounded to provide the hydrostatic head necessary to drive a water wheel used by a nearby flour mill. The impounded flow is diverted through the flour mill and re-enters the Cub River at Mile 6.4. During the summer months the entire flow of the river is impounded, resulting in a half-mile of dry stream bed below the dam. As this mill operates only during normal business hours, the stream flow below the mill fluctuates from high daytime flows to low nighttime and week end flows. During August the average day and night flows observed below the mill were 33 and 20 cfs, respectively, and during November were 50 and 30 cfs. A significant increase in flow below the mill as compared to that found above the mill was noticed both in August and November. This increase amounted to approximately 20 cfs during both of these surveys. In the absence of any known tributary flow it was concluded that springs were the source of this increased flow.

WORM CREEK

The headwaters of Worm Creek lie in the watershed adjacent to and west of the Cub River. Worm Creek flows west and south to where it enters the Cub River just below the State line. The upper Worm Creek stream bed is used to transport water diverted from Mink Creek and Cub River to the Glendale Reservoir where water from all three sources merge. Worm Creek below this reservoir carries little flow during the irrigation season. It collects some farm drainage and may collect surface runoff from the City of Preston as it flows southward at a distance of about a mile east of that city. South of Preston it is joined by the West Branch of the Cub River Canal. A short distance below this junction is a tainter gate control structure, the operation of which determines whether the total flow at that point continues on in the West Branch or flows south in the natural Worm Creek stream bed. From the start of irrigation season until such time as the runoff to Worm Creek becomes quite high, possibly as late as March or April, the flow in Worm Creek is diverted to the West Branch. During the high flow season the control gate is opened and the Worm Creek flow is released to its natural stream bed to the south and crosses the State line about three-quarters of a mile above its confluence with the Cub River.

Just above the State line an earthen dam has been constructed (1961) across Worm Creek. Water is impounded just prior to and during the irrigation season for use on adjacent lands. About the end of September the dam bypass is opened.

During both surveys the flow of Worm Creek below Preston was being diverted to the West Branch. In August the flow below the Worm Creek-West Branch confluence was 24 cfs while in November it was 7 cfs. The impoundment just above the State line was full during August and was spilling about 7 cfs. During November the dam bypass was open and a flow of 13.5 cfs was observed in Worm Creek just above the State line.

CUB RIVER CANAL

As already noted the main canal splits into the East and West Branches south of Preston. The West Branch picks up the flow in Worm Creek and flows southwesterly for about eight miles where it crosses the State line and for five miles farther into Utah. Just north of the State line the West Branch crosses a pump-supplied canal which carries 75 cfs from the Bear River during irrigation season. Most of this Bear River water is transferred to the East Branch which closely parallels the West Branch. Some Bear River water enters the West Branch, however, and during August brought the West Branch flow at the State line to 31 cfs. Just below the entrance of Worm Creek the West Branch flow was 24 cfs. The flow in the East Branch at the State line was 60 cfs during August and was largely made up of Bear River water. During November the Bear River pumps were not operating, and the flow in both the East and West Branches was quite low (less than 5 cfs).

There is a connecting canal between the two branches about three miles north of the State line which permits water to flow from the West to the East Branch. In November a small flow left the West Branch through this connecting canal. The usual manner of regulating flow in this canal is not known.

WASTE SOURCES

There are six major waste sources which discharge effluents to the surface waters of the area under study. They are the following:

1. Municipal Sewage Treatment Plant, Preston, Idaho;
2. Franklin Co. Sugar Company, Whitney, Idaho;
3. California Packing Corporation, Franklin, Idaho;
4. Amalgamated Sugar Company, Lewiston, Utah;
5. Pet Milk Company, Richmond, Utah;
6. Rocky Mountain Dairy, Smithfield, Utah.

The location of these waste discharges is shown in Figure 1. Two other waste sources were investigated; the Town of Lewiston and the California Packing Corporation at Smithfield. The sewerage system at Lewiston consists of two main sewers which collect septic tank effluent from less than fifty homes and a school. The effluents from the sewers are discharged to drainage ditches at a point about two to three miles west of the Cub River. Because of the low waste flow and long distance of travel to the Cub River, little effect on the quality of the river water could be detected as a result of this waste source. Therefore, although local problems may be associated with this waste, it is not considered to have a significant effect on the quality of the streams under consideration.

Similarly, the California Packing Corporation cannery at Smithfield disposes of its pea and corn processing wastes by land irrigation with the result that these wastes do not reach the Bear River. This plant operates only during the irrigation season (late June to mid-September) and the Smithfield Irrigation Company has reportedly contracted to accept all waste waters from the cannery.

PRESTON SEWAGE TREATMENT PLANT

This plant employs primary treatment for the municipal wastes of the City of Preston. Treatment steps include bar screens, sedimentation, separate sludge digestion, and effluent chlorination. Characteristics of the waste effluent are shown in Table 1. The effluent is discharged to Worm Creek a few hundred feet above its junction with the West Branch of the Cub River Canal. Except during periods of high runoff when the West Branch Canal is diverted to the natural Worm Creek stream bed, the Worm Creek flow containing this plant effluent is distributed by the West Branch Canal for irrigation and stock watering purposes.

This plant reportedly serves a population of 4000. The sewage flow averaged 250 gallons per capita per day, which is two to three times higher than would be expected, indicating that ground water infiltration to the sewerage system may be quite high. This same conclusion is borne out by the low BOD_5 concentrations found in the untreated sewage (30 to 40 ppm in one set of samples). A dye test of time of passage of the flow through this plant showed that detention in the clarifier was less than half the time period (four hours) normally used for design of such plants. The removal of settleable solids is apt to be less than complete in a plant operating under such conditions. This in turn makes adequate disinfection of the effluence by chlorination more difficult to achieve. Efficiency for BOD_5 removal by this plant is estimated to be 20% to 30%.

FRANKLIN COUNTY SUGAR COMPANY

This plant processes sugar beets during October and November and is idle during the other months of the year. It is classified as a straight house since the molasses which it produces is processed elsewhere. During November 1962, 1600 tons of beets were being sliced per day.

The plant's water supply is obtained from the West Branch of the Cub River Canal and its wastes are discharged to the otherwise dry Worm Creek stream bed between the West and East Branches of the canal. Waste treatment consists of a cinder pond and a lime pond. An overflow from the lime pond was reaching the stream during the November survey. The combined waste stream characteristics are shown in Table 1. This waste stream includes flume water, pulp screen water, pulp silo drainage, barometric condenser water, and lime pond overflow.

Table 1 shows that wastes discharged daily contained 33,300 pounds of BOD_5, equivalent to a population of 200,000 persons. Seven per cent of this was in settleable form. The plant also discharges 61,300 pounds of suspended solid materials each day.

AVERAGE WASTE DISCHARGE CHARACTERISTICS*

Table 1

					Suspended Solids	
Source	Location on Fig. 3	Flow (cfs)	BOD (ppm)	(5-day) (lbs/day)	(ppm)	(lbs/day)
August 1962						
Sewage Trtmt. Plant (Preston, Idaho)	1	1.6	47	450	39	316
California Packing Corp. (Franklin, Idaho)	3	0.92	207	1,020	63	313
Amalgamated Sugar Co. (Lewiston, Utah)	4	0.06	29	9	60	18
Pet Milk Co. (Richmond, Utah)	5	0.54	90	138	41	100
Rocky Mountain Dairy (Smithfield, Utah)	6	1.15	226	1,320	164	1,020
November 1962						
Sewage Trtmt. Plant (Preston, Idaho)	1	1.5	58	545	38	330
Franklin Co. Sugar Co. (Whitney, Idaho)	2	10.3	559	33,300	1,133	61,300
California Packing Corp. (Franklin, Idaho)	3	0.7	216	580	260	392
Amalgamated Sugar Co. (Lewiston, Utah)	4	1.0[a] 1.2[b]	3,800 177	20,500 1,185	67 7	380 54
Pet Milk Co. (Richmond, Utah)	5	0.27	94	226	39	44
Rocky Mountain Dairy (Smithfield, Utah)	6	0.48	> 193	> 400	74	166

*Bacterial densities are geometric means; all other values are arithmetic means.

a. pulp silo drainage
b. barometric condenser water

AVERAGE WASTE DISCHARGE CHARACTERISTICS*

Table 1 (Cont'd.)

Total Alkalinity (ppm)	pH	Temp. (°F.)	Bacterial Density (Nos. per 100 ml.) Total Coliform	Fecal Coliform	Strep. Group
278	7.7	64	1,940,000	340,000	64,000
211	7.2	84	3,500,000	1,600,000	2,700,000
540	8.6	64	510	4	350
265	7.9	77	2,900	630	2,700
376	8.6	86	176,000	52,000	27,000
256	7.5	59	55,600	8,560	6,490
268	6.5	66	1,660,000	21,000	1,160,000
199	7.2	59	556,000	87,000	900,000
347	4.8	92	110,000	5,620	1,200,000
186	6.5	97	6,020	1,620	9,000,000
177	8.2	99	6,840	1,300	180,000
311	8.2	68	126,000	28,200	---

Surveys conducted in 1955 and 1960 showed the population equivalent of this waste to be 380,000 and 258,000, respectively. This progressive reduction may be accounted for in part by the installation of a continuous diffuser in 1958 and by construction of a lime pond in 1961.

The total waste production for this type of plant would be expected to be near a figure of 43,000 pounds of BOD_5 at these processing rates.* Using this average figure it would appear that 25% of the wastes produced were being prevented from entering Worm Creek at the time of the November survey.

CALIFORNIA PACKING CORPORATION (FRANKLIN)

This plant cans peas, green beans, and sauerkraut. Peas are processed only when the cannery at Smithfield has insufficient capacity. Both green beans and cabbage are processed at the rate of 4000 tons per season. During the August survey green beans were being processed and during November sauerkraut was being produced.

Liquid wastes from green bean operations are discharged directly to the Cub River. During the sauerkraut season (October through January) wastes from the vat room and cutting room are discharged to a series of three ponds having an estimated total volume of about one acre-foot. All other wastes including those from the canning room are discharged directly to the river. These ponds are reportedly drained to the river during periods of high runoff in April, leaving sufficient volume to store all of the wastes discharged to them during sauerkraut canning operations.

---

* Black, H. H. and McDermott, G. N. "Industrial Waste Guide.--Beet Sugar," Sew. & Indus. Wastes, Vol. 24, No. 2 (Feb. 1952)

The waste characteristics in Table 1 indicate that 1020 pounds per day of BOD_5 are discharged while canning green beans and 580 pounds per day during the sauerkraut season. This effluent has very high bacterial densities during both seasons.

AMALGAMATED SUGAR COMPANY

This plant was slicing 1920 tons of sugar beets per day during the November survey. The Steffen's process is employed to process 130 tons of molasses per day, which are produced both at the Franklin County plant and at this plant. Extensive modifications to the waste system have been carried out in the last few years. These additions include a screening plant, grit chamber, clarifier, trickling filter and waste ponds.

Flume water is recirculated through the screening plant, grit chamber, clarifier, and trickling filter and none is discharged to the adjacent Cub River. Barometric condenser water is obtained directly from the Cub River and by pipeline from High Creek, and supplies make-up water to the flume system before being discharged to the river. Pulp screen water and the underflows from the grit chamber and clarifier are discharged to a 20-acre storage pond. This pond also receives the 20-acre lime pond overflow and filter cloth washing wastes. Steffen's waste is discharged to a 20-acre evaporation pond. Pulp silo drainage and cinder waste are discharged directly to the river.

The total organic waste load reaching the river was found to be 20,500 pounds of BOD_5 per day and is due almost entirely to the pulp silo drainage. Barometric condenser water not used as make-up in the flume circuit represents about 3% of the waste load. The contents of the main storage pond, which is full by the end of the campaign in December, are discharged to the Cub River during high spring flows. Attempts are being made to treat the pond contents on the trickling filter during the summer, but some difficulties have been encountered. During the August survey the contents of the main waste pond were being passed through the trickling filter. The pond was nearly empty, however, and in order to maintain the flow rate to the filter, unpolluted High Creek water was being added to the pond accounting for the very low strength of the waste and the resulting poor slime growth observed on the trickling filter rock.

Waste production for a Steffen's house plant at these processing rates would normally be expected to be about 80,000 pounds of BOD_5 per day.* Considering the waste discharge rate observed in November of 20,000 pounds per day it would appear that 75% of the waste produced is withheld from the stream. If means could be provided for eliminating the pulp silo drain discharge as, for example, by installing a pulp drier or increasing existing pond capacity, the waste discharge from this industry could be nearly eliminated. Survey results in 1955 showed a waste discharge of 57,700 pounds of BOD_5 per day, which indicates the extent of waste reduction achieved since that time.

---

* loc. cit., pg. 14

PET MILK COMPANY

This plant processes whole milk to produce canned evaporated milk. Process wastes are discharged without treatment to a ditch at a point one and one-half miles east of the Cub River. The exact amount of this flow which reaches the river is not known, but is undoubtedly small during the growing season. At other times most of the flow discharged may reach the river.

The characteristics of this waste effluent are shown in Table 1 for August and November. Organic waste loads were found to be 138 and 226 pounds per day, respectively. The 1955 survey indicated a waste load of 103 pounds per day. In August, milk receipts at the dairy averaged 132,000 pounds per day during the survey. Capacity for evaporating 350,000 pounds of raw milk per day is available, but peak receipts do not ordinarily exceed 170,000 pounds per day.

ROCKY MOUNTAIN DAIRY

This dairy produces bottled milk, cream, powdered milk, cottage cheese, Swiss cheese, powdered whey and butter. Peak activity in 1962 occurred in May when over 14 million pounds of raw milk were received by the plant. Of this, 4.24 million pounds were processed into cheese. During the August survey when milk receipts were at about 60% of the peak level, the waste load discharged from the plant averaged 1320 pounds of BOD_5 per day. During November an average daily load in excess of 400 pounds per day was found. Results of a survey carried out in November 1955 indicated that waste production averaged 1045 pounds per day except when cheese making was suspended in which case waste production was 523 pounds per day. Although no treatment is given these wastes prior to discharge, it was reported that in November the application of whey wastes to land was being attempted on a trial basis.

This effluent is discharged to the Bear River just west of Smithfield, seven miles below the entrance of the Cub River. During the irrigation season some portion of this waste flow is intermittently applied to cultivated acreage adjacent to the dairy.

MISCELLANEOUS WASTE SOURCES

In addition to the major waste sources described above there are numerous small sources of liquid wastes throughout the area under study. During the growing and harvesting seasons the valley uses large amounts of migrant labor. This labor is housed partially in camps which consist of barracks-type housing. At least three such camps were observed adjacent to the streams under study. While the organic load contributed to the streams by this temporary housing is probably not significant since their population is well under one hundred in each case, any bacterial contamination would be of significance. It was reported that septic tanks were usually employed.

Return water from irrigation drainage enters the system at many points and this contribution to pollution of the streams is difficult to assess accurately. Because of the large numbers of dairy and beef cattle raised in the area, the visibly polluted condition of some of these drainage waters is undoubtedly of animal origin.

A large turkey farm and a trout hatchery were observed adjacent to the Bear River west of Smithfield. These potential waste sources should be considered when interpreting stream water quality data.

STREAM CONDITIONS

Field surveys of the streams in the area were carried out from July 31 to August 15, 1962, and again from November 1 to November 16, 1962. Thus, stream conditions were observed during the irrigation season and later when irrigation has ceased, and sugar beet processing was underway. The streams were sampled at each of the stations shown in Figure 1 or 26 locations in all. At least 20 samples were obtained at each station and these were spread over the 24 hours of the day. Analyses were conducted for dissolved oxygen (DO), 5-day biochemical oxygen demand (BOD_5), suspended solids, hydrogen ion concentration (pH), alkalinity, temperature, and bacterial content. At each of these stations and at several other supplementary locations as well, a biological examination of the stream was conducted. The following pages summarize the stream conditions found during both surveys.

CHEMICAL CHARACTERISTICS

Tables 2 and 3 summarize the analytical stream water quality data for conditions as found during the August and November surveys, respectively. The following narrative discusses these findings for each of the streams, proceeding in a more or less north to south direction.

Upper Worm Creek - August

The upper Worm Creek flows into the West Branch Canal which in turn ultimately crosses the State line into Utah. The Preston Sewage Treatment Plant effluent enters Worm Creek just above its junction with the West Branch Canal. During the summer water samples were collected from this sytem at six locations, which are shown in Figure 1 (in downstream order, Stations W16.1, W7.5, CW10.5, CW7.2, CW4.6, and CW2.8). In addition, the East Branch Canal at the State line was sampled (CE6.7).

Station W16.1 was typical of unpolluted waters having a low BOD_5 and high DO content. About nine miles downstream, just above the Preston Sewage Treatment Plant, some indications of slightly lowered quality were present, probably due to drainage from agricultural lands and inhabited areas just east of Preston. The effects of the Preston effluent could be readily observed at CW10.5 below the confluence of Worm Creek and the West Branch Canal, where BOD_5 and suspended solids concentrations had doubled but were still relatively low due to the five-fold dilution afforded by the high quality canal water. Conditions in the West Branch Canal were improved just above the State line by virtue of the increased flow resulting from the addition of water from the Bear River. Both the East and West Branch Canals at the State line were of comparable chemical quality, which did not in itself reflect significant chemical pollution.

Lower Worm Creek - August

This stretch of Worm Creek is normally dry during the irrigation season and was found in this condition in August. However, some agricultural drainage does find its way to the lower end of the creek and samples were obtained at one location (W2.0) just above the impoundment (Figure 1) in Idaho. This flow showed some evidence of pollution of unknown origin, having a BOD_5 content of 5.2 ppm and a median DO level of only 4.4 ppm. After passing through the impoundment, this flow enters the Cub River just below the State line.

Cub River - August

At C15.0 the Cub River was found to be relatively free of pollution with a mean BOD_5 of 2.2 ppm. Some agricultural drainage was undoubtedly present, which promoted algal activity causing the DO to fluctuate between 4.9 and 13.2 ppm. The median value was found to be 5.9 ppm. Following the entrance of the California Packing Corporation effluent, the next downstream Station C13.6 was found to be severely polluted. Eighty per cent of the time the Cub River at this location was totally devoid of oxygen and the BOD_5 averaged 21.5 ppm. BOD_5 concentrations as high as 59 ppm were found. The presence of a dam located 0.6 miles downstream contributed to the poor condition of the river at this station. This dam, which is closed during irrigation season, causes a backwater condition at C13.6, which reduces reaeration there and permits complete oxygen depletion to take place. Water is pumped (Franklin-Cub pumps) from this impoundment for irrigation use in Idaho and in Utah. The pumping operation is manually controlled to utilize almost the entire flow of the river with the result that the river bed below the dam is quite often dry. Some water does escape due to leakage and periodic spilling. Over the irrigation season this flow is estimated to average 2 cfs.

The next accessible sampling location on the Cub River during irrigation season is in Utah at C9.6. The flow here contains the contribution from Worm Creek and had an average BOD_5 concentration of 10.2 ppm. The suspended solids were very high at 230 ppm and the median DO concentration was 3.9 ppm. Values as low as 1.4 ppm were found during the survey. Gas bubbles were observed breaking the surface, indicating active decomposition of bottom sludge. The water was extremely dark and turbid. The high solids content of the water was probably due to the sludge brought from the bottom by gas bubbles which formed there as a result of anaerobic decomposition. As will be described later, 10,000 pounds of solids originating in the Franklin County Sugar Company waste are deposited each day in this stretch of the river during the sugar beet campaign. These solids are the only apparent source of the decompsoing sludge observed during August at this station.

During August an almost negligible flow was discharged by the Almalgamated Sugar Company just downstream from C9.6. No effects of this discharge could be noted or would be expected at the next station downstream, C6.4. About 0.5 mile above this station there is a dam across the Cub River. Water impounded behind this dam is released to a canal, which leads to a flour mill located adjacent to the Cub River at C6.4. This canal terminates in a steep channel at the mill where a water wheel is driven by the falling water. After passing through the mill the water re-enters the Cub River. The total amount of water returned to the river was found to exceed that which was withdrawn by approximately 20 cfs. This large increase in flow was also observed during November and is attributed to ground water accretions upstream of the dam. As a result of this dilution, stream conditions were markedly improved at C6.4 where the BOD_5 and suspended solids dropped to 3.9 ppm and 75 ppm, respectively, while the DO increased to 6.8 ppm. Stream water quality at the next two downstream stations (C3.6 and C0.8) was similar to that found at C6.4. The BOD_5 at C0.8 was slightly higher (4.7 ppm) than at C3.6 where it was 4.1 ppm. This increase may be attributable to the waste discharged by the Pet Milk Company.

Bear River - August

The Bear River 11.0 miles below the State line at B68.5 was high in DO (7.2 ppm) and low in BOD_5 (2.9 ppm). One mile below the confluence with the Cub River at B63.0 the DO was essentially unchanged, although an increase in BOD_5 to 3.4 ppm was found as a result of the addition of Cub River water. At the next station downstream (B57.5), which is below the entrance of the Rocky Mountain Dairy, the BOD_5 showed another slight rise to 3.6 ppm and the median DO level was 7.6 ppm. Other chemical characteristics as shown in Table 2 were very similar at all three stations on the Bear River.

Upper Worm Creek - November

At this time of the year most of the flow in the West Branch Canal is removed by the Franklin County Sugar Company for process water leaving little dilution for Worm Creek, which contains the Preston Sewage Treatment Plant effluent. As a result the BOD_5 concentration in the canal below Worm Creek was 24 ppm or six times higher than during the summer months. Although samples from stations farther down the canal were not taken in November, a BOD_5 concentration of approximately 15-20 ppm would be expected at the State line in the West Branch Canal. No water is pumped from the Bear River in November so the beneficial effects of dilution from this source were not present.

Lower Worm Creek - November

The waste effluent from the Franklin County Sugar Company constitutes the entire flow in Worm Creek at W6.2. As a result the entire lower Worm Creek to its junction with the Cub River in Utah is highly polluted. At W6.2 the BOD_5 in the stream was 599 ppm and suspended solids were 1133 ppm. Dissolved oxygen ranged from 2 to 5.5 ppm with a median value of 3.4 ppm. The flow averaged 10.3 cfs indicating that 33,000 pounds of BOD and over 61,000 pounds of solids (dry weight) passed this station each day.

Four miles downstream at W2.0 the flow had increased by 30% to 13.5 cfs, which together with biochemical degradation had caused the BOD_5 concentration to drop to 423 ppm and suspended solids to 838 ppm. The DO at this station was below one ppm at all times and completely depleted 50% of the time. An earthen dam across the stream just below this station creates an impoundment during irrigation season, but in November the bypass at the dam was open, allowing the creek flow to pass through the dam. The creek flow was slowed sufficiently, however, to allow 45,000 pounds of suspended solids to deposit each day behind the dam. Over the 60-day sugar beet campaign in October and November this

AVERAGE STREAM WATER QUALITY CONDITIONS
AUGUST 1962

Table 2

Station*	Flow (cfs)	BOD (5-Day) (ppm) Min	BOD (5-Day) (ppm) Mean	BOD (5-Day) (ppm) Max	Suspended Solids (ppm)	Dissolved Oxygen (ppm) Min	Dissolved Oxygen (ppm) Median	Dissolved Oxygen (ppm) Max
W16.1	-	0.4	1.2	5.1	57	6.6	8.5	9.5
W 7.5	3.1	1.3	2.8	> 7.5	74	6.1	7.0	8.6
CW12.4	17.1	1.0	2.1	4.3	29	7.1	9.0	12.0
CW10.5	16.6	2.7	4.3	6.5	56	4.9	7.4	10.8
CW 7.2	16.0	2.4	4.7	6.8	38	6.1	7.6	9.5
CW 4.6	30.7	2.0	2.8	6.4	43	6.5	7.2	8.1
CW 2.8	30.7	1.4	2.6	5.0	34	4.7	7.1	16.1
CE 6.7	60.2	1.6	2.7	4.6	66	6.3	7.4	11.4
W 2.0	7.5	2.1	5.2	14.6	52	1.2	4.4	10.8
C15.0	4.0	0.7	2.2	6.3	47	4.9	5.9	13.2
C13.6	4.8	1.9	21.5	59.2	28	0.0	0.0	4.7
C 9.6	9.5	3.8	10.2	32.3	230	1.4	3.9	10.5
C 6.4	27.0	2.2	3.9	5.6	75	3.9	6.8	9.9
C 3.6	27.0	2.6	4.1	5.9	97	6.1	7.1	9.6
C 0.8	27.0	2.7	4.7	6.4	100	2.7	7.0	10.6
B68.5	509.0	2.0	2.9	3.9	118	6.5	7.2	8.3
B63.0	535.0	2.3	3.4	> 6.7	99	6.5	7.3	8.3
B57.5	535.0	2.2	3.6	5.4	87	6.6	7.6	8.8

*** Station numbers represent miles above the mouth of the stream (or terminus of the canal).**

AVERAGE STREAM WATER QUALITY CONDITIONS
AUGUST 1962
Table 2 (Cont'd.)

			Bacterial Density (Nos. per 100 ml.)		
Total Alkalinity (ppm)	pH	Temp. (°F.)	Total Coliform	Fecal Coliform	Strep. Group
144	8.5	55	1,000	100	790
311	8.1	62	42,000	5,400	36,600
179	8.4	60	3,700	700	1,700
214	8.2	62	79,000	12,000	6,300
229	8.3	63	70,000	7,200	4,800
294	8.5	67	10,000	2,000	2,200
311	8.5	68	7,700	1,500	1,700
310	8.5	69	2,900	650	2,700
310	8.0	68	24,800	1,300	14,000
250	8.5	67	3,700	1,100	800
252	7.7	69	9,700,000	2,500,000	160,000
351	8.2	69	7,670	1,500	10,000
266	8.1	62	6,500	1,100	4,000
277	8.0	64	4,600	650	3,400
277	8.2	68	3,100	500	4,300
316	8.5	69	1,400	400	4,000
324	8.4	69	1,360	430	2,300
319	8.4	69	5,500	2,800	12,000

would amount to almost 3 million pounds of material. The useful life of the impoundment will be seriously shortened by this yearly addition of the equivalent of 200 to 300 dump truck loads of soil each year.

Some aeration of the creek takes place below the dam resulting in slightly higher DO levels, above 3.3 ppm in half of the samples, just below the State line at Station W0.7. The BOD_5 is essentially unchanged (422 ppm) from the station just above the dam, although deposition has lowered the suspended solids concentration to 191 ppm. Just below this station Worm Creek joins the Cub River.

Cub River - November

Above all waste discharges at C15.0 the Cub River is high in quality with chemical characteristics typical of an unpolluted stream (BOD_5, 1.7 ppm: DO, 9.6 ppm). At the next station 1.4 miles downstream (C13.6) the waste discharge from the California Packing Corporation has caused obvious changes. The DO here was found to be as low as 3.0 ppm and had a median value of 5.8 ppm. The BOD_5 averaged 22.9 ppm, but reached levels as high as 75 ppm when the packing plant was in full production.

After irrigation season the checks are removed from the dam just below this station and the full river flow enters Utah.

Below the State line in Utah at C11.3 the dissolved oxygen level in the river was below 3.7 ppm half the time, the lowest value observed being 1.2 ppm. The BOD at this station averaged 4.5 ppm; the highest value found was 11 ppm.

Just below this station the Cub River is joined by Worm Creek. The Cub River flow of 5.1 cfs added 120 pounds/day of BOD_5 and 858 pounds/day of solids, while Worm Creek's flow of 13.5 cfs added 30,600 pounds/day of BOD_5 and 14,700 pounds/day of solids to the combined flow of these two streams below their junction. Thus, the polluted character of the Cub River at C9.6, 1.5 miles below this junction, is primarily the result of the addition of the Worm Creek flow. Between this junction and Station C9.6, 10,700 pounds of solids were deposited on the Cub River stream bed each day, leaving a suspended solids concentration of 37 ppm at C9.6. Dissolved oxygen at Station C9.6 was never found above 1.7 ppm, while 17% of the samples were totally depleted. The BOD_5 averaged 262 ppm.

The Cub River just below this station is used as a source of barometric condenser water (1-2 cfs) by the Amalgamated Sugar Company. After this use the water is returned to the river at a higher temperature (97°F.), but otherwise improved in quality as a result of dilution by High Creek water, which is also used as condenser water. This plant also discharges approximately one cfs of drainage water from the pulp silo, which has a BOD_5 concentration of 3,800 ppm. Thus, 20,500 pounds/day of BOD_5 are added to the 28,000 pounds/day already present in the stream. This plant also discharges its cinder water directly to the river, adding large but unmeasured quantities of cinder ash, which readily settles forming a partial dam which restricts flow and impounds the stream for a short distance.

About three miles below this waste discharge is the small dam across the Cub River used to provide water power for the flour mill adjacent to Station C6.4. As was found during the summer, approximately 20 cfs is added at this point providing a 1:1 dilution of the polluted Cub River. As a result, the river BOD_5 at C6.4 was 210 ppm, less than found at C9.6 in spite of the large amount of waste material added by the Amalgamated Sugar Company. On a mass flow basis the 48,900 pounds/day of BOD_5 which should have been in the river below the Sugar Company was found to be 44,200 pounds/day at Station C6.4, reflecting the expected amount of BOD_5 degradation in this three mile stretch of stream. The suspended solids content was 26 ppm, indicating an increase of about 1,500 pounds/day in the stream, probably due to fine cinder material discharged by the sugar mill. The stream DO was improved slightly by dilution, although 30% of the time it is less than one ppm and was never found to rise about 5 ppm.

The river shows a slight but steady decrease in BOD_5 due to self-purification at the last two stations above its mouth. At C3.6 and C0.8 the BOD_5 was found to be 193 and 170 ppm, respectively. The suspended solids remained constant at 29 ppm. Dissolved oxygen levels at C3.6 were similar to the next upstream station: 38% of the samples contained less than 2 ppm DO, and the DO was less than 3 ppm in 75% of the samples. The maximum value observed was 3.8 ppm.

At C0.8, however, DO conditions were the poorest found anywhere on the Cub River with total depletion occurring over half the time, primarily at night. It was noted previously that flow in the Bear River is much higher at night, while the Cub River was lowest at night due to the regulation of these rivers for power production. This situation caused a backwater condition in the Cub and a virtual cessation of flow at C0.8 during the nighttime hours. This seriously diminished stream reaeration and promoted the depleted oxygen conditions in the lower mile of the Cub River.

Bear River - November

The Bear River was actually sampled at four different locations above the entrance of the Cub River. These stations were at B68.5, 76.5, 83.3, and B89.5. Two of these were in Utah and two were above the State line in Idaho. All of these stations exhibited similar quality characteristics and have been combined in Table 3 as B68.5. The BOD_5 of these samples was unaccountably high for what should be an unpolluted stream, having an average concentration in excess of 5.5 ppm (two samples exhibited a demand beyond the oxygen available in the sample itself). The DO was near or above saturation levels at all of these locations and had a median value of 10.4 ppm.

BACTERIOLOGICAL QUALITY

The coliform group of bacteria is used as the classical indication of pollution. The fecal coliform group, as measured by gas production from lactose at 44.5°C. (±0.250) is comprised of coliforms known to be

AVERAGE STREAM WATER QUALITY CONDITIONS
NOVEMBER 1962
Table 3

		BOD (5-Day) (ppm)				Dissolved Oxygen (ppm)		
Station*	Flow (cfs)	Min	Mean	Max	Suspended Solids (ppm)	Min	Median	Max
W 9.1	2.0	1.7	2.5	4.1	40	8.7	10.4	1.0
CW12.4	14.0	0.9	2.1	> 6.4	10	7.7	11.0	18.0
W 6.5	7.0	9.4	24.1	47.9	90	5.1	6.3	7.9
W 6.2	10.3	322.0	599.0	1212.0	1133	2.0	3.4	5.5
W 2.0	13.5	315.0	423.0	703.0	838	0.0	0.0	0.6
W 0.7	13.5	250.0	422.0	943.0	191	0.0	1.1	3.3
C15.0	4.4	1.1	1.7	5.5	19	8.5	9.6	14.7
C13.6	5.1	3.1	22.9	65.8	31	3.0	5.8	9.6
C11.3	5.1	1.9	4.5	10.8	32	1.2	3.7	8.3
C 9.6	19.0	66.0	262.0	413.0	37	0.1	0.5	1.7
C 6.4	39.0	130.0	210.0	286.0	26	0.3	2.0	5.1
C 3.6	39.0	159.0	193.0	284.0	29	0.8	2.3	3.8
C 0.8	39.0	122.0	170.0	224.0	29	0.0	0.0	2.9
B68.5	390.0	1.6	5.5	> 7.6	91	9.2	10.4	11.6
B63.0	430.0	10.1	21.4	41.8	89	7.9	9.5	11.0
B57.5	430.0	7.2	19.9	230.0	63	7.2	9.3	11.4

* Station numbers represent miles above the mouth of the stream (or terminus of the canal).

AVERAGE STREAM WATER QUALITY CONDITIONS
NOVEMBER 1962

Table 3 (Cont'd.)

			Bacterial Density (Nos. per 100 ml.)		
Total Alkalinity (ppm)	pH	Temp. (°F.)	Total Coliform	Fecal Coliform	Strep. Group
302	8.3	41	5,560	2,300	1,300
191	8.5	42	974	145	245
347	7.9	49	40,000	4,300	11,500
268	6.5	66	1,660,000	21,000	1,160,000
352	7.2	55	4,200,000	80,000	4,060,000
335	7.2	53	2,250,000	55,700	1,650,000
270	8.3	44	460	110	160
268	7.9	45	34,000	2,450	7,660
273	7.9	43	11,000	100	346
319	7.4	48	707,000	9,120	655,000
307	7.5	49	760,000	7,560	326,000
320	7.6	48	475,000	4,030	100,000
305	7.5	46	306,000	1,800	60,000
350	8.4	46	560	140	440
348	8.2	46	69,400	480	5,240
340	8.3	46	60,000	1,200	5,230

derived from the fecal excreta of warm-blooded animals. This contrasts with the total coliform group which may have other origins as well. The streptococcal group was used as a supplementary indicator of pollution. All bacterial densities are reported in Tables 1, 2, and 3 and in the following text as a geometric mean density (numbers per 100 ml.) for each sample location. The geometric mean has been found by experience to be a better measure of central tendency than an arithmetic mean for bacterial densities in streams and waste flows. Each station was sampled between 20 and 26 times over a one to two week period.

Upper Worm Creek - August

The bacterial densities at the station furthest upstream (W16.1) were the lowest found at any of the stream locations during August (see Table 2) and are indicative of the lack of a significant amount of pollution at that location. Station W7.5, the next station downstream, showed very great increases in all bacterial groups. The densities at W7.5 were 42, 54, and 46 times greater than those at W16.1, for total coliform, fecal coliform, and the streptococcal group, respectively. Station W7.5 is located downstream from the City of Preston but above the Preston Sewage Treatment Plant. Thus, pollution of fecal origin enters Worm Creek in the 8.6 stream miles between these two stations.

The effluent from the Preston Sewage Treatment Plant had a total coliform density of approximately 2 million (Table 1) as it was discharged to Worm Creek. The creek, which had a total coliform density of 42,000 just above the discharge point (W7.5), provided a 2 to 1 dilution for the treatment plant flow. The combined flow in Worm Creek then enters the West Branch of the Cub River Canal just a few hundred feet below the waste discharge point. The higher quality canal waters had a total coliform density of 3700 (CW12.4) above the entry of Worm Creek and a density of 79,000 at the first station (CW10.5) monitored below this junction. Although the Worm Creek stream flow was less than one-third that of the canal, its very high bacterial density caused a more than twenty-fold increase in the total coliform density of the canal waters. A similar increase was observed in the fecal coliform densities as well.

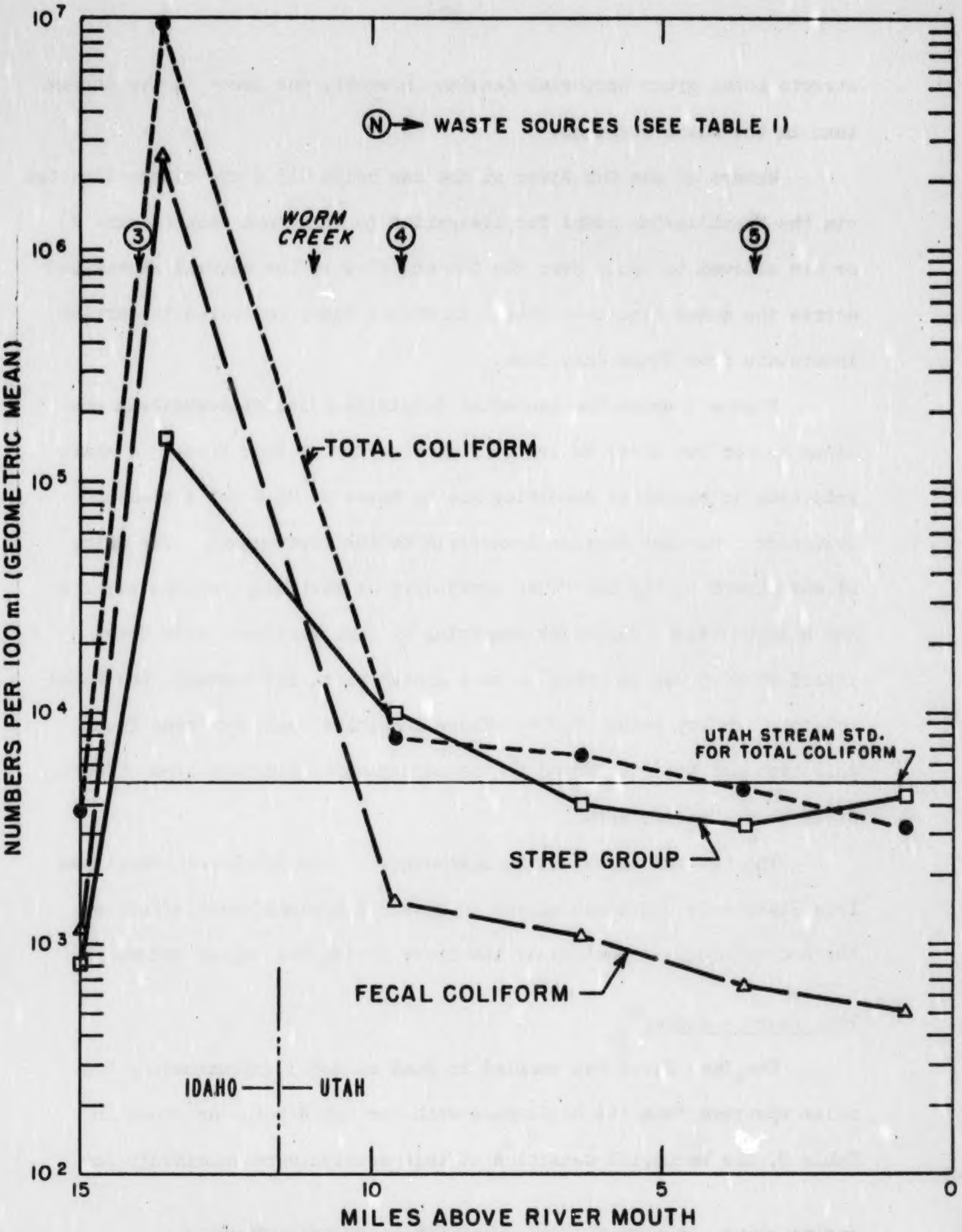
Below Station CW10.5 the total coliform density decreased slightly to 70,000 and the fecal coliform to 7200 at CW7.2. At the Utah-Idaho State line, CW4.6, the flow in the West Branch Canal is made up largely of Bear River water, which is pumped to the West and East Branch Canals just above the State line (see Figure 1). Since the Bear River bacterial densities are quite low at this point (i.e., total coliform of 1400 and fecal coliform 400) the much higher densities in the West Branch Canal are greatly reduced by dilution to 10,000 total coliform and 2000 fecal coliform at the State line. Without this dilution by Bear River water, bacterial densities in the West Branch Canal at the State line would probably be three to six times greater.

The East Branch Canal receives no treatment plant effluent, although some contaminated West Branch Canal water may enter the East Branch through the interconnecting canal shown in Figure 1. This may account in part for the slightly higher total coliform density (2900) in the East Branch Canal at the State line than that of the Bear River water (1000), which makes up a large portion of the canal flow at this point.

It is concluded from the findings discussed above that bacterial pollution originating from the City of Preston, Idaho, is carried interstate in the West Branch of the Cub River Canal.

Lower Worm Creek and Cub River - August

Samples from the uppermost station on the Cub River, C15.0, contained relatively low bacterial densities, although somewhat higher than similar background or unpolluted stations on Worm Creek (W16.1) and the Bear River (B68.5). Just above the next downstream station on the Cub River, (C13.6), bean canning waste effluent from the California Packing Corporation enters the river. The very large bacterial densities in this effluent (Table 1) cause large increases in the bacterial densities of the Cub River as measured at C13.6 and shown in Figure 3. The densities at this point of 9.7 million for total coliform, 2.5 million for fecal coliform and 160,000 for the streptococcal group represent increases of 2600, 2300, and 180 times, respectively, over the densities measured in the river at C15.0. The bacterial concentrations at C13.6 were the highest observed at any of the stream stations during August and except for the streptococci were also higher than the stream densities observed during the November survey. It may be noted also that stream bacterial densities at C13.6 were significantly higher even than those found in the cannery effluent itself which was the cause of these high stream densities. This occurred in the case of total and fecal coliforms as a result of nutrients added by the waste and environmental conditions conducive to bacterial growth which exist in the backwater of the small dam located 0.6 miles downstream from C13.6. The



CUB RIVER BACTERIAL DENSITIES - AUG. 1962

FIGURE 3

streptococcal group bacterial density, however, was lower in the stream than in the waste effluent.

Waters of the Cub River at the dam below C13.6 are either diverted via the Franklin-Cub pumps for irrigation in Idaho and Utah (Figure 1) or are allowed to spill over the dam and flow in the natural stream bed across the State line into Utah. In either case, pollution is carried interstate from Idaho into Utah.

Figure 3 shows the bacterial densities found at downstream stations in the Cub River to its confluence with the Bear River. A sharp reduction in bacterial densities may be noted at C9.6 and a gradual reduction from that station downstream to the river mouth. The entry of Worm Creek to the Cub River above C9.6 is partially responsible for the high bacterial densities remaining at that station. Worm Creek itself at W2.0 was observed to have a high bacterial content, the total coliform density being 24,800. These densities represent some fecal pollution and are attributed to the agricultural drainage area of Worm Creek above Station W2.0.

The two industrial waste discharges to the Cub River downstream from Station C9.6 did not appear to have had a significant effect on the bacteriological quality of the river during the August survey.

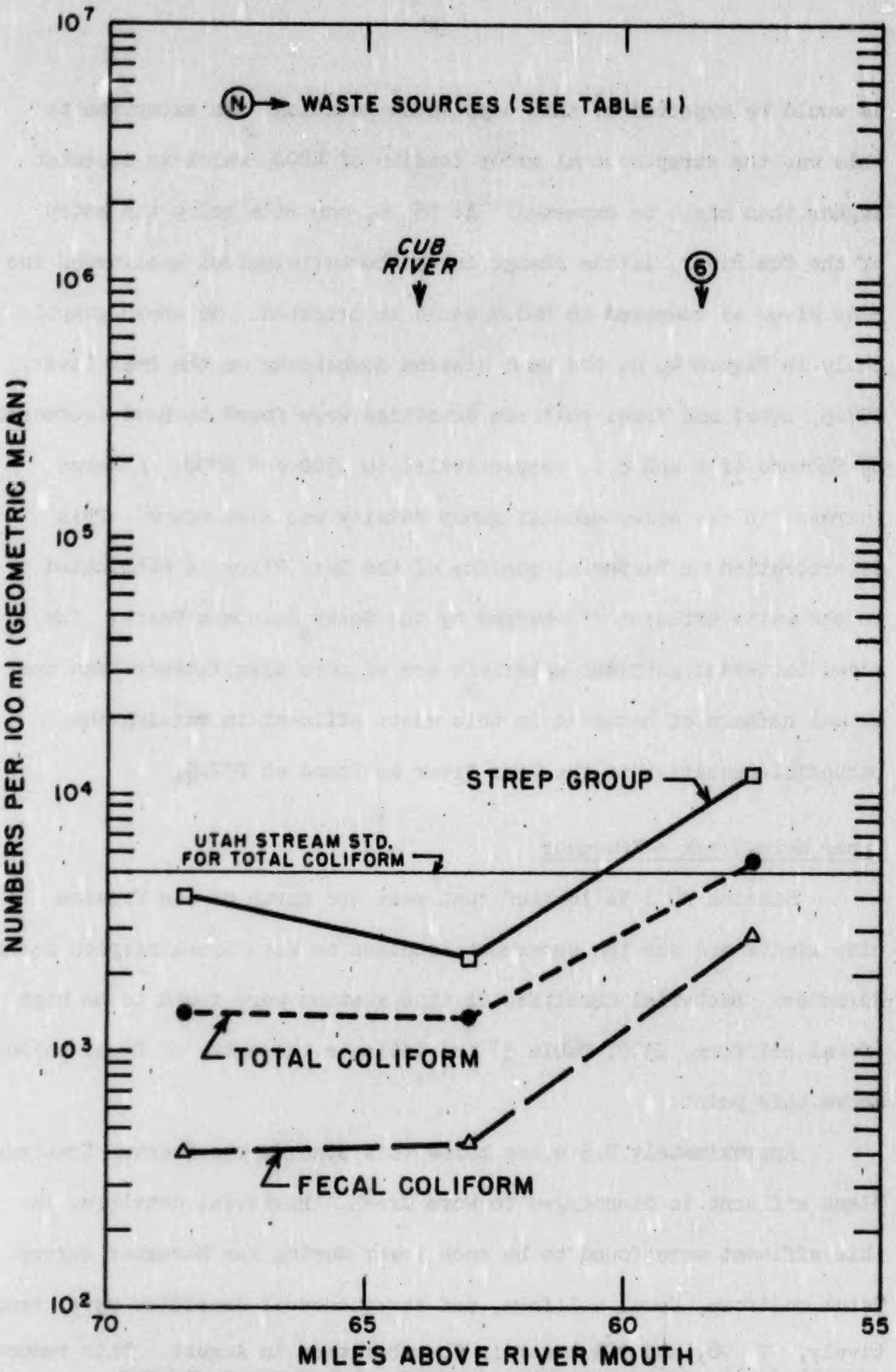
Bear River - August

The Bear River was sampled in Utah at B68.5 approximately 4.5 miles upstream from its confluence with the Cub River. As shown in Table 2, the bacterial densities at this station were relatively low as would be expected of this unpolluted location. An exception to this was the streptococcal group density of 4000, which is somewhat higher than might be expected. At B63.0, one mile below the entry of the Cub River, little change in the bacteriological quality of the Bear River as compared to B68.5 could be detected. As shown graphically in Figure 4, at the next station downstream on the Bear River, B57.5, total and fecal coliform densities were found to have increased by factors of 4 and 6.5, respectively, to 5500 and 2800. A large increase in the streptococcal group density was also noted. This deterioration in bacterial quality of the Bear River is attributed to the waste effluent discharged by the Rocky Mountain Dairy. The added bacterial nutrient materials are of more significance than the actual numbers of bacteria in this waste effluent in raising the bacterial densities in the Bear River as found at B57.5.

Upper Worm Creek - November

Station W9.1 is located just east and north of the Preston city limits and was the uppermost location on Worm Creek sampled during November. Bacterial densities at this station were found to be high (fecal coliform, 2300, Table 3) and indicate the entry of fecal pollution above this point.

Approximately 2.5 miles below this station the Preston Treatment Plant effluent is discharged to Worm Creek. Bacterial densities in this effluent were found to be much lower during the November survey. Total coliform, fecal coliform, and streptococcal densities were, respectively, 97, 98, and 90% lower in November than in August. This reduction



BEAR RIVER BACTERIAL DENSITIES-AUG. 1962

FIGURE 4

may be attributed primarily to improved effluent chlorination and to a lesser degree to the slightly lower sewage temperatures existing in November.

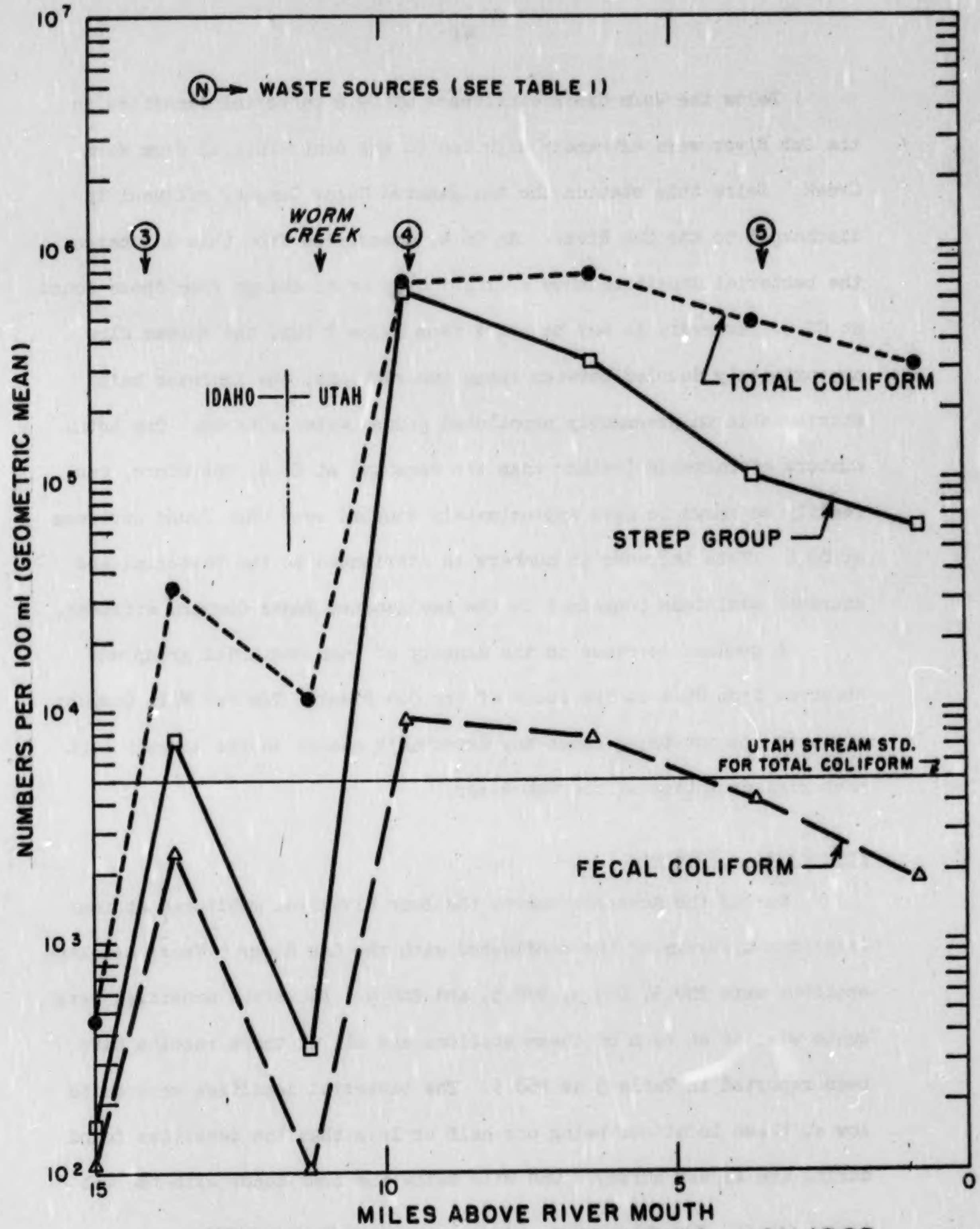
The West Branch Canal just above Worm Creek at CW12.4 had quite low densities, the total coliform density of 974 being 75% lower than found during August. The lower autumn densities which were also found at other unpolluted locations in the basin can be attributed generally to the change in agricultural practices occurring with the end of the irrigation season in late summer. Water temperatures were approximately 20°F. lower in the fall, and these lower temperatures tend to reduce bacterial aftergrowth.

Bacterial densities resulting from the mixing of West Branch Canal waters with those of Worm Creek containing the Preston effluent, were found (at W6.5) to be 40, 30, and 20 times higher respectively for the total coliform, fecal coliform and streptococci than those found at CW12.4 just above Worm Creek. The total coliform density in the West Branch Canal below Worm Creek was 40,000 or roughly one-half the density found at a nearby station (CW10.5) during the summer. Although stations on the lower West Branch Canal were not monitored during the November survey, it would be expected that higher densities would be found at the State line (CW4.6) in November than in August. Since water is not diverted from the Bear River to the West and East Branch Canals in November, the reduction in densities due to dilution noted during August at CW4.6 would not occur in the fall. This was borne out by findings of the November 1960 survey, which showed total coliform densities in excess of 20,000 in both the East and West Branch Canals at the state line.

Lower Worm Creek and Cub River - November

The flow in Worm Creek at W6.2 (Table 3) is made up entirely of waste effluent from the Franklin County Sugar Company. The bacterial densities at this station were extremely high, with the total coliform density being 1.66 million, fecal coliform 21,000, and streptococci 1.16 million. At a distance of 4.2 miles downstream (W2.0) large increases in the densities of each group were noted. This bacterial multiplication resulted from high waste water temperatures (66°F. at W6.2) and the presence of bacterial nutrient materials in the waste effluent. At W0.7 in Utah just below an impoundment where large amounts of suspended solids drop out on the creek bed, bacterial densities showed reductions by 50% or more in each of the three bacterial groups as compared with W2.0. The densities at W0.7 remained at high levels, however, the total coliform density being 2.25 million, fecal coliform 55,700, and the streptococcal group 1.65 million. Just 0.7 miles below this last Worm Creek station is the confluence with the much less polluted Cub River.

The uppermost station on the Cub River, C15.0, had the lowest bacterial densities observed at any location during the November survey. The entry of the California Packing Corporation sauerkraut canning waste caused large increases in the stream bacterial densities as shown in Figure 5. At Station 11.3 below the State line in Utah, the fecal coliform and streptococcal densities had dropped markedly to the levels found at C15.0, although the total coliform density remained high, having a value of 11,000.



CUB RIVER BACTERIAL DENSITIES - NOV. 1962

FIGURE 5

Below the Worm Creek confluence at C9.6 bacterial densities in the Cub River were extremely high due to the contributions from Worm Creek. Below this station the Amalgamated Sugar Company effluent is discharged to the Cub River. At C6.4, downstream from this discharge, the bacterial densities show a slight drop or no change from those found at C9.6. However, it may be noted from Table 3 that the stream flow approximately doubled between these two stations, the increase being attributable to presumably unpolluted ground water sources. The total numbers of bacteria (rather than the density) at C6.4, therefore, can readily be shown to have approximately doubled over that found upstream at C9.6. This increase in numbers is attributed to the bacterial and nutrient additions contained in the Amalgamated Sugar Company effluent.

A gradual decrease in the density of each bacterial group was observed from C6.4 to the mouth of the Cub River. The Pet Milk Company effluent did not bring about any detectable change in the already high bacterial densities of the Cub River.

Bear River - November

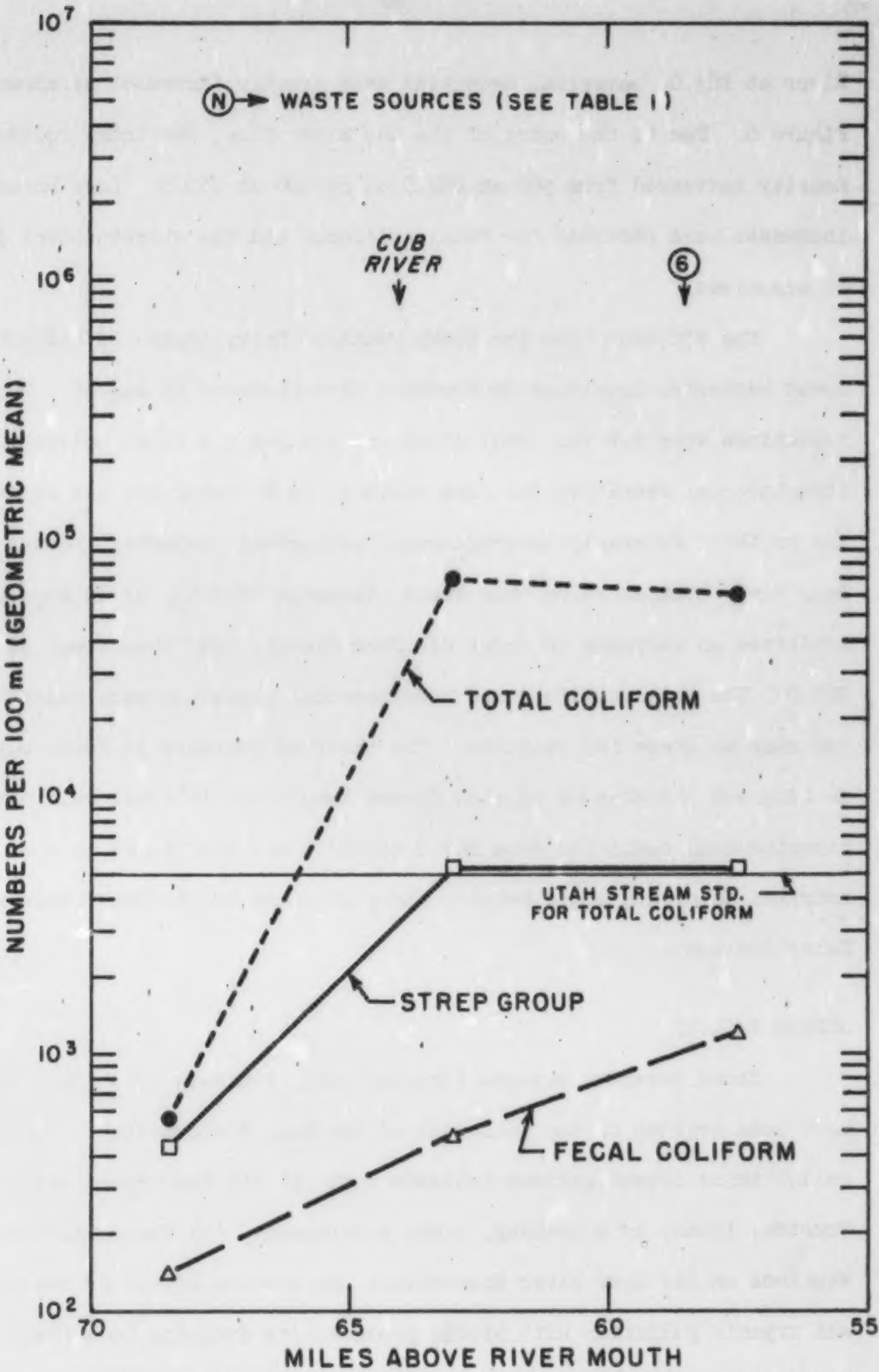
During the November survey the Bear River was monitored at four locations upstream of the confluence with the Cub River. These sampling stations were B89.5, B83.3, B76.5, and B68.5. Bacterial densities were quite similar at each of these stations and all of these results have been reported in Table 3 as B68.5. The bacterial densities were quite low at these locations being one-half or less than the densities found during the August survey. One mile below the confluence with the Cub

River at B63.0, bacterial densities were greatly increased as shown in Figure 6. Due to the entry of the Cub River flow, the total coliform density increased from 560 at B68.5 to 69,400 at B62.0. Less marked increases were observed for fecal coliforms and the streptococcal group of organisms.

The effluent from the Rocky Mountain Dairy (Table 1) contained lower bacterial densities in November than observed in August. These reductions were 72% for total coliforms and 54% for fecal coliforms. Streptococcal densities for this effluent in November are not reported due to their extremely heterogeneous biochemical characteristics. The Bear River station below this waste discharge (B57.5), as in August, exhibited an increase in fecal coliform density over that found at B62.0. The total coliform and streptococcal densities were essentially the same at these two stations. The observed increase in fecal coliform density and the absence of significant reductions in total coliform and streptococcal densities from B62.0 to B57.5 are attributed to the nutrient materials added between these stations by the Rocky Mountain Dairy effluent.

STREAM BIOLOGY

Three previous reports (October 1952, February 1955, July 1960) have been written on the pollution of the Bear River system. Biologically, these investigations indicate that (1) the Bear River north of Preston, Idaho, is a healthy, clean environment, (2) the downstream stations on the Bear River demonstrate the adverse effect of inorganic and organic pollution with biotic productivity dropping to a trace, and



BEAR RIVER BACTERIAL DENSITIES-NOV. 1962

FIGURE 6

(3) the Cub River and Worm Creek were normal environments in their upper reaches, but seriously polluted in their lower reaches. The 1955 report* states that "the Bear River from Preston, Idaho, to Cutler Reservoir is virtually a biological desert insofar as bottom life is concerned."

A biological investigation measures the kind and quantity of life that inhabits a stream. Benthic organisms that usually have life cycles of one year or longer are especially suitable for evaluating streams since they reflect bottom conditions over a period of several months. Many factors including (1) light, (2) temperature, (3) dissolved gases, (4) food supply, (5) type of bottom substrate, (6) water depth, and (7) current velocity affect the number, as well as the kind of organisms that inhabit the aquatic environment. A change in any one of these factors will change the biota.

Rock and coarse gravel offer the most suitable bottom habitat; decreasing benthic productivity is correlated with decreasing particle size of substrate. Fine sand, because of its small surface area and shifting nature, offers little habitat to organisms.

Most bottom organisms are not equipped to move great distances; they are subjected to all adverse factors entering the habitat. Some forms cannot adjust to changes within the habitat and are killed, whereas others can tolerate severe environmental changes. Organic pollution, for example, will cover the bottom substrate, with sludge drastically increasing the food supply and decreasing the dissolved oxygen. Such environmental changes are sufficient to kill intolerant benthic forms (immature stoneflies, caddisflies, mayflies, etc.), but because of decreased predation and abundant food supply, offers ideal conditions for tolerant forms (sludgeworms and certain midge larvae). Thus, an unpolluted stream will support many different kinds of organisms, while a stream carrying organic wastes will support a large benthic population, but only two or three tolerant species.

---

* Report on the Investigation of Pollution in the Bear River System Idaho-Utah. U. S. Dept. of Health, Education, and Welfare, Public Health Service, Sanitary Engineering Services, Region IX, Water Supply and Pollution Control Program, February 1955. (Mimeo)

Inorganic silt covers the bottom substrates and eliminates living spaces for benthic forms. It does not, however, offer a rich food supply; the silt suppresses benthic production of all forms.

The Bear River biological study included bottom organisms, fish, attached algae and slimes. Three types of bottom samplers were used: the Ekman dredge, the Petersen dredge, and the Surber Stream Bottom sampler. In addition, artificial substrates* were employed at several stations on the Bear River because the shifting sand bottom was not conducive to the development of a benthic community. These were constructed from three inch squares of masonite, and were placed in the water for three weeks to serve as an attachment site for benthic forms. In all cases where practical, benthic samples were collected from the same type of substrate to facilitate comparisons between stations.

---

* Slightly modified from sampler described by Hessler, F. E. and Dendy, J. S., "A Multiplate Sampler for Artificial Macro-invertebrates," Transactions American Fisheries Soc., 91(4): 420-421, October 1962.

Quantitative population studies were performed at all stations in addition to qualitative sampling. All quantitative samples were sieved through a U. S. standard No. 30 screen and preserved for later identification and counting in the laboratory. Samples of fish populations, collected in conjunction with the Utah Department of Fish and Game, were obtained by means of a piscicide (Rotenone). The fish so collected were identified and counted and fish stomachs were retained for a determination of food content.

Cub River

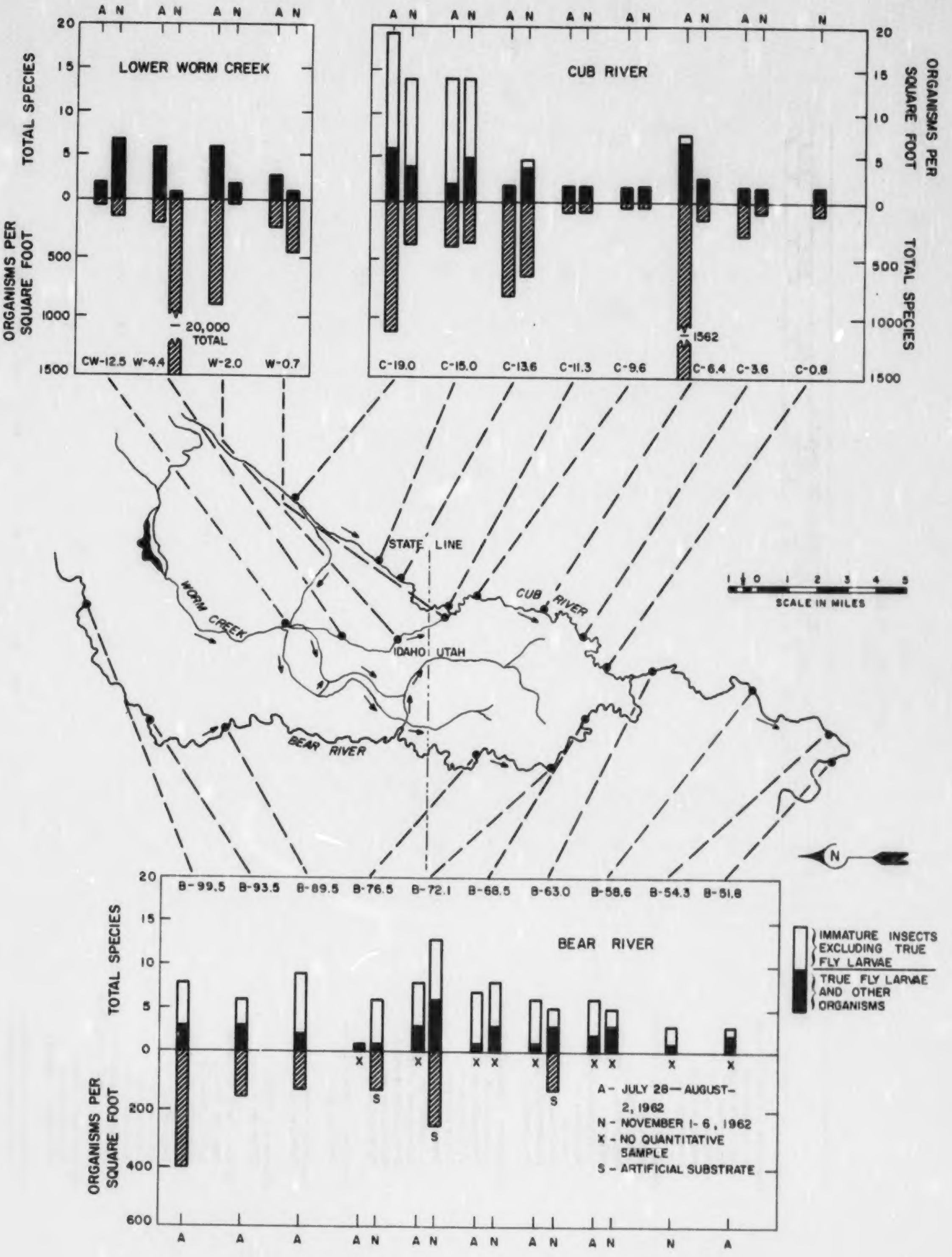
Eight stations were sampled on the Cub River ranging from mile C-19.0 to mile C-0.8 (Figure 7). At river mile C-19.0 and C-15.0, large numbers of intolerant species were found (for example, immature stonefly naiads, mayfly naiads, caddisfly larva and aquatic beetle larva) and relatively few individuals were represented in any one species, signifying a normal stream environment (Table 4). These intolerant species, whose oxygen requirements are great, possess large external gills to collect the dissolved oxygen from the water. The substrate in this reach of river ranged from rock to coarse gravel. A green alga (Cladophora) covered the rocks at river mile C-15.0. At river mile C-19.0 the river offers excellent trout habitat, and during the fall survey fish eggs were collected and tentatively identified as trout.

Following the introduction of California Packing Company wastes above C-13.6 the over-all number of species was greatly reduced, intolerant species were eliminated, and the production in numbers of individuals greatly increased. During the fall, pollutional conditions were more severe, with large populations of sludgeworms growing on the cabbage wastes. The bottom substrate at this station was fine sand covered with a half inch of sludge. Blue-green attached algae (Oscillatoria, Lyngbya and Spirulina) covered the sludge. A filamentous bacterium (Sphaerotilus natans), known as sewage fungus, was observed on the sticks and rocks in the stream.

The Cub River became seriously degraded as it flowed from Idaho into Utah (C-12.0). In the course of seven miles it was changed from a trout stream to one that supported only the most tolerant benthic organisms.

At river mile C-11.3 above the Worm Creek confluence only sludgeworms and midges were found. The bottom was composed of hard clay and supported very few organisms. Sludge was not observed either in the summer or fall; the water was very turbid and sluggish. Below the Worm Creek confluence (C-9.6), the Cub River was still very sluggish and very few intolerant organisms inhabited the stream bottom. In the fall small amounts of sludge were observed. During the summer survey numerous carp and green sunfish were observed at river mile C-9.6. In the fall, however, no fish were observed.

At mile C-6.4 a long riffle enhances reaeration. The bottom fauna were diversified in the summer and contained some tolerant as well as intolerant caddisfly larvae. The fall collection on this riffle consisted only of leeches, bloodworms, and sludgeworms, and the rock substrate was covered with a gray mat composed of sewage fungus (Sphaerotilus natans) which greatly reduced the benthic population (Figure 7). Sludge



BENTHOS DATA— BEAR RIVER SYSTEM
1962

FIGURE 7

Table 4

BENTHOS DATA - CUB RIVER
1962

Organisms[1]	Number of Organisms Per Square Foot															
	C-19.0		C-15.0		C-13.6		C-11.3		C-9.6		C-6.4		C-3.6		C-0.8	
	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N
Plecoptera - Stonefly Naiad																
Arcynopteryx sp.		1														
Perlinella drymo		1	1													
Brachyptera sp.	6															
Isogenus sp.	2	9	37	2												
Pteronarcella sp.		2														
Acroneuria sp.			1													
Ephemeroptera - Mayfly Naiad																
Baetis sp.	38			4												
Centroptilum sp.	19															
Ephemerella, 3 species	*	39	4													
Ameletus			4													
Paraleptophlebia sp.				2												
Heptagenia sp.	5	2		2												
Iron sp.			4													
Hexagenia sp.				*												
Tricorythodes sp.			6													
Callibaetis sp.				*		*										
Trichoptera - Caddisfly Larvae																
Leptocella sp.	83	6														
Pycnopsyche sp.	2															
Glyphopsyche sp.	*															
Protoptila sp.	2															
Brachycentrus Americanus	928	300	10													
Parapsyche sp.		6														
Hydropsyche betteni			250	112							4					
Hydropsyche recurvata			9	81												
Hydropsyche sp.			5													
Rhyacophila sp.	1															
Coleoptera - Beetle Larvae																
Neoelmis sp.	7	3	41	36												
Amphipoda - Scud																
Gammarus sp.				*							2					
Pulmonata - Snails																
Physa sp.		1				*										
Diptera - True Fly Larvae																
Hexatoma spinosa	3	1		5												
Antocha saxicola	1	1														
Euparyphus sp.	1															
Simuliidae	20		3	4												
Pericoma sp.		2														
Hydrobaeninae	3			100												
Pentaneura sp.	5															
Polypedilum sp.											516					
Tendipes plumosus-tentans-Bloodworm					14	304	22	44	8	2	12	18	17	16		70
Small Green Midge			*			120										
Rhynchobdellida-Leech																
Glossiphonia sp.				1							8	8				
Helobdella stagnalis											8					
Oligochaeta - Aquatic Worms																
Tubificidae-Sludgeworms					800	200	54	40	18	32	1012	98	253	48		12
Total Species	19	14	14	14	2	5	2	2	2	2	7	3	2	2		2
Total Organisms/sq. ft.	1126	374	375	349	814	624	76	84	26	34	1562	124	270	64		82

* Appeared Only in Qualitative Sample

[1] Tentative Identification

A - July 28 - August 2, 1962

N - November 1-6, 1962

was also mixed in with the stones.

On July 10, 1962, the Utah Department of Fish and Game made a fish survey at river mile C-6.4 on one-sixth mile of stream by means of an electroshocker. Their collection consisted of carp, green sunfish, chub, whitefish, brown trout and bullhead. The next day, however, the brown trout and green sunfish were observed dying. The dissolved oxygen measured 9.3 and the pH measured 8.6; the cause was, therefore, undetermined.

At stations C-3.6 and C-0.8 the bottom fauna during both periods was suppressed to tolerant sludgeworms and bloodworms, with relatively few individuals. The substrate at these stations was composed of fine sand and in the fall sludge was mixed in the sand at station C-3.6. Sphaerotilus was observed at C-3.6 covering the twigs and other debris in the stream in the fall.

On July 11, 1962, the Utah Department of Fish and Game made two fish surveys, one at C-3.6 and the other at C-0.8. The collection at C-3.6 consisted of carp and bullhead while the collection at C-0.8 consisted of bullhead, green sunfish, carp, sucker, and yellow perch. No fish were visibly observed at any of the stations from river mile C-13.6 to C-0.8 during the November biological survey.

Upper Worm Creek

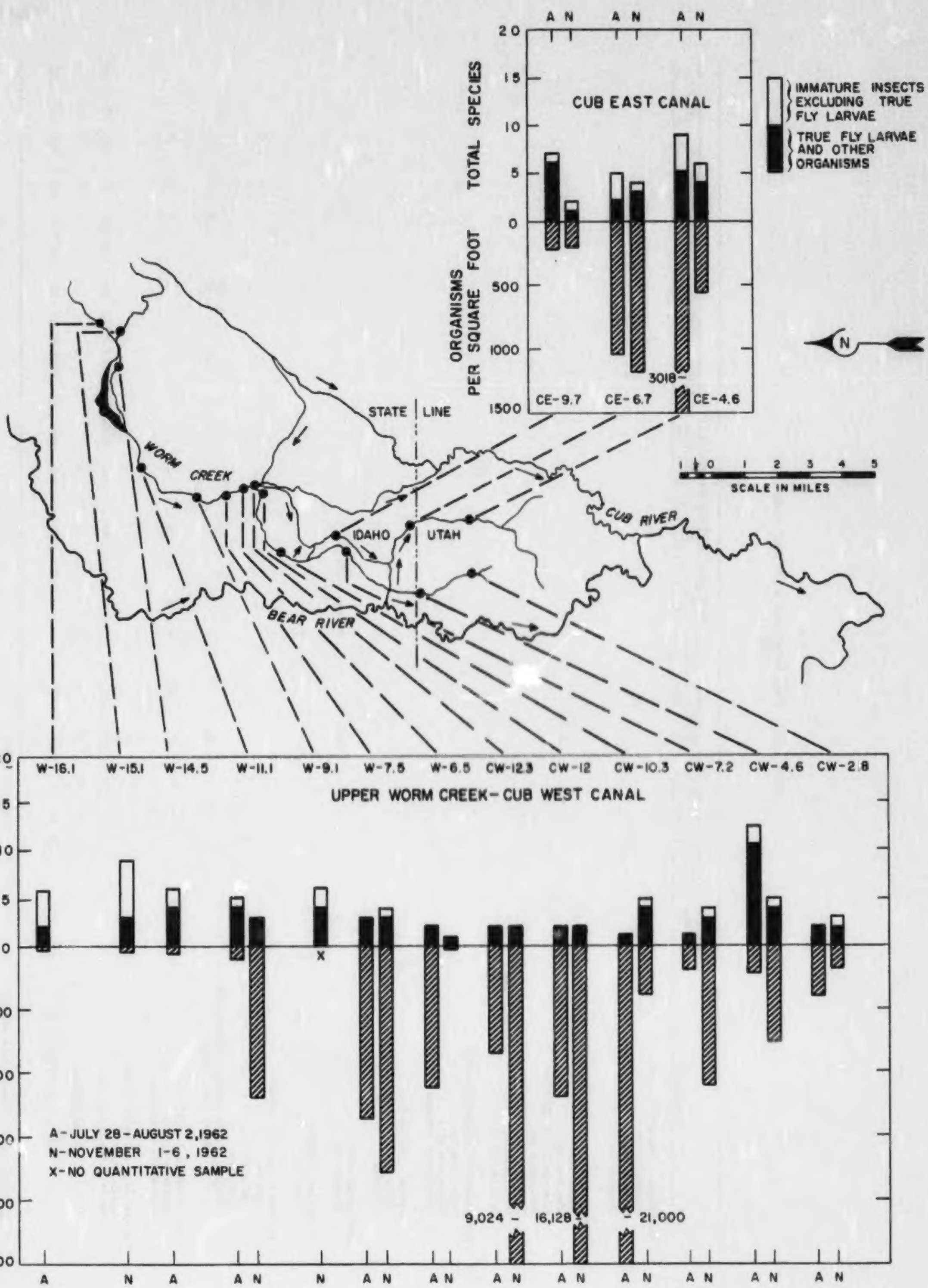
Stations W-16.1 and W-14.5 on upper Worm Creek were in balance with a large number of intolerant species such as stonefly naiads, mayfly naiads, and caddisfly larva being present (Figure 8). The numbers of each of these species were relatively low, but made up a high proportion of the total number of organisms in the stream (Table 5). High water velocities coupled with a substrate of rock and boulders offers some trout fishing providing flows are held at a relatively constant state.

A drastic change took place between W-14.5 and W-11.1 resulting from the removal and return of irrigation water. At W-11.1 the intolerant mayflies were very limited in August. The remaining population was made up of tolerant bloodworms, sludgeworms and leeches. During the fall survey the intolerant mayflies were eliminated. The substrate at W-11.1 was composed of sand ans silt loam.

Just above the confluence of sewage treatment plant effluent at Preston, Idaho, (W-9.1 and W-7.5) few intolerant immature mayflies and caddisflies were collected during the fall survey. The number of tolerant sludgeworms had increased to almost 1,000 per square foot in a bottom substrate of silt loam. Sago pondweed (Potamogeton pectinatus) covered the bottom at W-7.5.

The West Branch of the Cub River Canal above the Franklin County Sugar Company water intake (CW-12.5) was in an unbalanced state. The fluctuating water levels at this station contribute to the biotic instability. In November CW-12.5 contained numerous tolerant species such as crane fly, horse fly larvae and Physa snails. During the summer, however, only the more tolerant species were present. The bottom substrate at this station was a fine sand covered with a thin layer of silt. Cladophora was growing profusely at this station.

The biota at CW-12, because of flow reversal caused by the Sugar Company water intake, was composed of only tolerant organisms; the population of sludgeworms increased 100 fold from August to November.



BENTHOS DATA—BEAR RIVER SYSTEM
1962
FIGURE 8

Table 5

BENTHOS DATA - UPPER WORM CREEK & CUB WEST CANAL
1962

	Number of Organisms Per Square Foot																									
	W-16.1		W-15.5		W-14.5		W-11.1		W-9.1		W-7.5		W-6.5		CW-12.3		CW-12		CW-10.5		CW-7.2		CW-4.6		CW-2.8	
Organisms[1]	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N
Plecoptera - Stonefly Naiad																										
Acroneuriinae	*																									
Nemoura sp.				2																						
Isogenus sp.				7																						
Ephemeroptera - Mayfly Naiad																										
Baetis sp.												*														
Ameletus sp.	27						8																			
Ephemerella, 3 species				12																						
Heptagenia sp.	*				*																					
Iron sp.					*																					
Tricorythodes sp.																							6			
Callibaetis sp.																				*		*				16
Trichoptera - Caddisfly Larvae																										
Leptocella sp.				6																			20			
Parapsyche sp.				9																						
Hydropsyche betteni				6						*																
Coleoptera - Beetle Larvae																										
Agabus sp.	2																									
Ischnura sp.										*																
Amphipoda - Scud																										
Gammarus sp.							12			*	152	800														
Pulmonata - Snails																										
Physa sp.				2						*																
Diptera - True Fly Larvae																										
Tabanidae																							4	8		
Tipulidae				3				4															2			
Simuliidae	1				*																		120			
Tendipes plumosus-tentans-Bloodworm														8						128					384	
Small Green Midge	2			6	52		28									384		128		96		128	6	8		
Rhynchobdellida-Leech																										
Glossiphonia sp.							*	4		*	24	12	16		2		4			32		32	4	8		
Helobdella stagnalis					*					*													6	8		4
Oligochaeta - Aquatic Worms																										
Oligochaetes					4																		8			
Tubificidae-Sludgeworm							80	1200			1558	1000	1120		840	8640	1200	16000	21000	160	200	960	50	720	24	168
Total Species	6			9	6		5	3		6	3	4	2	1	2	2	2	2	1	5	1	4	10	5	2	3
Total Organisms/sq. ft.	32			53	56		128	1208			1734	1812	1136	8	842	9024	1204	16128	21000	416	200	1120	226	752	408	188

* Appeared only in Qualitative Sample

[1] Tentative Identification

A - July 28 - August 2, 1962

N - November 1-6, 1962

During August the biota (Table 5) remains essentially the same as the water flows from Worm Creek (W-6.5) into the West Branch of the Cub River Canal (CW-12.0). The benthos at these two stations was composed entirely of tolerant bloodworms and sludgeworms, and at CW-12 achieved tremendous populations (over 16,000 per square foot). The substrate in this reach remained the same as above, which was a sandy silt loam. Sphaerotilus was growing profusely on the twigs at W-6.5 and drifted down in floating masses to CW-12. In the fall, however, the Sphaerotilus at W-6.5 was greatly reduced and no floating flocs were observed. Organic sludge deposits undergoing active decomposition and emitting hydrogen sulfide gas were prevalent at W-6.5 in November. A thin layer of sludge covered the sand at CW-12. During November sago pondweed was observed growing on the banks of the canal. A reduction in flow during November permitted the sludge to settle out at CW-12.

At station CW-10.5 a tolerant immature mayfly (Callibaetis) was collected near the shoreline. The substrate in this area was an organic sludge mixed with silt overlying a clay bed.

At station CW-7.2 the biota remained essentially unchanged; sludgeworms were the dominant organism. The substrate in this area was a fine sand overlaying a clay bottom. Sphaerotilus was actively growing on rocks and twigs along the canal banks. The environment of Cub West at the State line was biologically degraded in November. The types of organisms that inhabited the canal in November were those associated with organic enrichment. The contrast between stations CW-7.2 and CW-4.6 (Table 5) was the result of water that was pumped from Bear River into

Cub West. In August at CW-4.6 intolerant forms were present in moderate numbers and tolerant forms were present in relatively few numbers (40 per square foot). By November pumping of Bear River water had been suspended and the intolerant immature mayflies were eliminated. Sludgeworms increased in abundance to 700 per square foot. The substrate in this area was a fine sand and during August supported a green alga (Cladophora). This alga was eliminated in November. The recovery at CW-4.6 during the summer was temporary since all intolerant forms had been eliminated at CW-2.8 and only very tolerant bloodworms and sludgeworms were present. The substrate in this area was a fine silt loam and was covered with long filaments of a green alga (Cladophora). The edges of the canal were lined with sago pondweed.

The total number of organisms in the East Branch of the Cub River Canal at CE-9.7 remained relatively the same during August and November, but a reduction in species took place during the fall with the change in its source of water. The substrate at this station was a silty loam and was lined during the summer period with pondweed.

The improvement of Cub East at CE-6.7 (Table 6) was a result of the pumping of Bear River water into the canal. This was evidenced by the appearance of such intolerant forms as immature mayflies and caddisflies. Similar conditions were present in both the summer and fall even with no Bear River water entering the canal in the fall.

Station CE-4.6 was essentially the same as CE-6.7; intolerant forms were present at the station. The substrate at stations CE-6.7 and CE-4.6 was composed of fine sand. Cub East contained intolerant

Table 6

BENTHOS DATA
CUB CANAL, CUB EAST CANAL, AND LOWER WORM CREEK
1962

Organisms[1]	Number of Organisms Per Square Foot													
	CW-12.5		CE-9.7		CE-6.7		CE-4.6		W-4.4		W-2.0		W-0.7	
	A	N	A	N	A	N	A	N	A	N	A	N	A	N
Ephemeroptera - Mayfly Naiad														
Ameletus sp.							6							
Hexagenia sp.						48	4	24						
Ephoron sp.					24									
Tricorythodes sp.					2		8							
Trichoptera - Caddisfly Larvae														
Leptocella sp.					12		24							
Coleoptera - Beetle Larvae														
Agabus sp.				12										
Hydroporinae			8											
Gomphus sp.								8						
Amphipoda - Scud														
Hyalella azteca			*											
Gammarus sp.								100			*			
Pulmonata - Snails														
Physa sp.		16	8				2		*		*	4		
Helisoma sp.											*			
Diptera - True Fly Larvae														
Tabanidae		20						8						
Tipulidae		16												
Simuliidae		4							*				*	
Spaniotoma	36													
Tendipes plumosus-tentans-Bloodworm						16			44		66			
Small Green Midge			16		6		6				*		*	
Rhynchobdellida-Leech														
Glossiphonia sp.		24	20			8	2		*					
Helobdella stagnalis		12	4				2	32	*					
Oligochaeta - Aquatic Worms														
Tubificidae-Sludgeworms	10	60	164	200	1020	1120	3054	400	164	20,000	830	24	220	440
Total Species	2	7	7	2	5	4	9	6	6	1	6	2	3	1
Total Organisms/sq. ft.	46	152	220	212	1064	1192	3018	572	208	20,000	896	28	220	440

* Appeared Only in Qualitative Sample

1 Tentative Identification

A - July 28 - August 2, 1962

N - November 1-6, 1962

organisms as it flowed from Idaho into Utah, however, organic enrichment was evidenced by the presence of a large population (3,000 per square foot) of sludgeworms.

Lower Worm Creek

The Lower Worm Creek (Table 6) was almost completely dry during the August survey, and the restricted flow was not sufficient to allow recovery of the benthos. The benthos during August is represented by six species of tolerant organisms such as leeches, scuds and *Physa* snails. In the fall, however, these were completely eliminated and replaced by a large population (20,000 per square foot) of very tolerant sludgeworms at W-4.4 (Figure 9). Below the Franklin County Sugar Company outfall sludge beds consisting of beet tops and pulp achieved depths of 36 inches or more (Figure 10). The sludge in this area was so dense and thick that its demand on the dissolved oxygen for decomposition restricted the population of sludgeworms to the canal banks where limited reaeration took place. *Sphaerotilus* was present at W-4.4 during August, but was not present during the November survey because of the lack of oxygen in the water.

Another adverse effect of the effluent from the Franklin County Sugar Company was the foam resulting from the calcium carbonate waste. This foam (Figure 11) covered the creek from bank to bank and, for a significant distance, it was dense enough that it restricted light required for algal photosynthesis.

The biota at stations W-2.0 and W-0.7 remained essentially unchanged as Worm Creek entered the Cub River. The bottom organisms were composed mainly of very tolerant sludgeworms and bloodworms. Sewage fungus was present at both of these stations during the August and November surveys. The substrate was composed of fine sand and silt. During the fall survey, however, beet pulp covered the bottom and in some parts was 18 inches deep. In August a green alga (Cladophora) grew at W-0.7; this was replaced by a blue-green alga (Oscillatoria) in the fall.

Worm Creek as it flowed from Idaho into Utah (W-1.0) supported only tolerant organisms. Below the State line Worm Creek was not conducive to the development of a balanced biological population because of fluctuating water levels and organic enrichment.

Bear River

Ten stations were sampled on the Bear River from mile 99.5 to mile 51.8 (Figure 7). Table 7 illustrates the large diversity of organisms found at river miles 99.5 and 93.5. The substrate in this area was a long series of riffles which was conducive to the development of a wide variety of organisms. The riffle area from Preston, Idaho, north to Oneida Dam was interspersed with deep clear pools and offers excellent trout fishing. It supports a large population of fish food organisms (400-500 per square foot).

At station B-89.5 below Five Mile and Deep Creeks intolerant forms such as caddisfly and mayfly larvae have been reduced (Figure 7). Mayflies are of the genus Tricorythodes which can withstand large amounts of silt (Table 7). The substrate at B-89.5 was composed of small amounts of fine gravel and small particles of sand. The river from B-89.5 down to Cutler Reservoir (mile B-51.8) was silt-laden.

Table 7

BENTHOS DATA - BEAR RIVER
1962

	Number of Organisms Per Square Foot																			
	B-99.5		B-93.5		B-89.5		B-76.5		B-72.1		B-68.5		B-63.0		B-58.6		B-54.3		B-51.8	
Organisms[1]	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A	N
Ephemeroptera - Mayfly Naiad																				
Baetis, 3 spp.	5				9															
Ameletus sp.	130				17															
Ephemerella sp.					1															
Heptagenia sp.								3	*	*	*		*					*		
Stenonema sp.								33		50	*	*	*		*					
Tricorythodes sp.	56		75		40			2	*	87	*	*	*		*	*				
Callibaetis sp.																				*
Trichoptera - Caddisfly Larvae																				
Hydropsyche recurvata	7		4		4			22	*	3										
Hydropsyche betteni	51		2		1			42		10	*	*	*	98		*				
Hydropsyche sp.					1				*	60	*	*	*	14	*			*		
Polycentropus interruptus										*	*	*			*					
Coleoptera - Beetle Larvae																				
Neoelmis sp.									*											
Amphipoda - Scud																				
Hyalella azteca	5				2				*	3		*		*	*					*
Diptera - True Fly Larvae																				
Simuliidae	10								16	4		*								
Polypedilum sp.	125		20				*		*											
Tendipes plumosus-tentans-Bloodworm														3S/76E		4				
Small Green Midge								33		27	*	*	*	20	*			*		*
Rhynchobdellida-Leech																				
Glossiphonia sp.			26							1										
Helobdella stagnalis			18							1										
Oligochaeta - Aquatic Worms																				
Oligochaetes										1						4				
Tubificidae-Sludgeworms					60											28				
Total Species	8		6		9		1	6	8	13	7	8	6	5	6	5		3		3
Total Organisms/sq. ft.	389		145		135			135-S	16	247-S				132-S 208		36				

* Appeared Only in Qualitative Sample

1 Tentative Identification

S Artificial Substrate

A - July 28 - August 2,1962

N - November 1-6, 1962

E - Ekman Dredge Sample

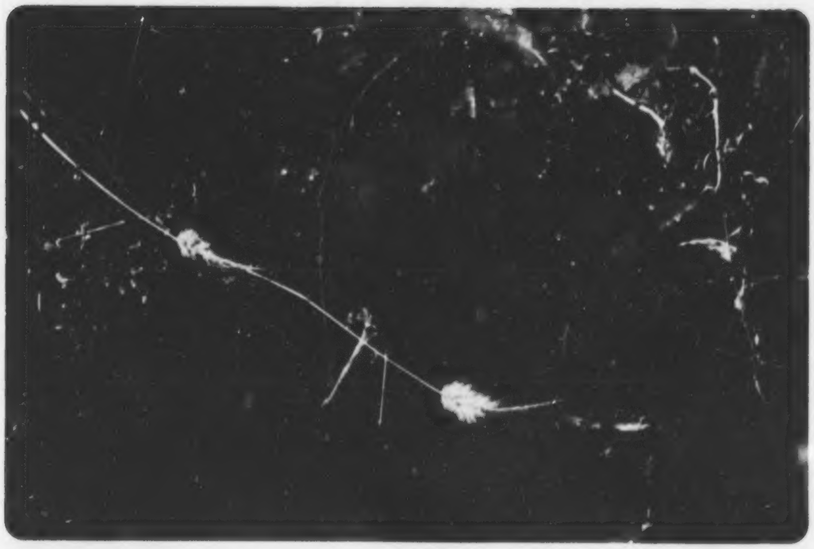


Figure 9

SLUDGEWORMS IN WORM CREEK AT W-4.4

November 3, 1962, 2:15 PM

Figure 10

SLUDGE IN WORM CREEK AT W-4.4

November 3, 1962, 2:20 PM

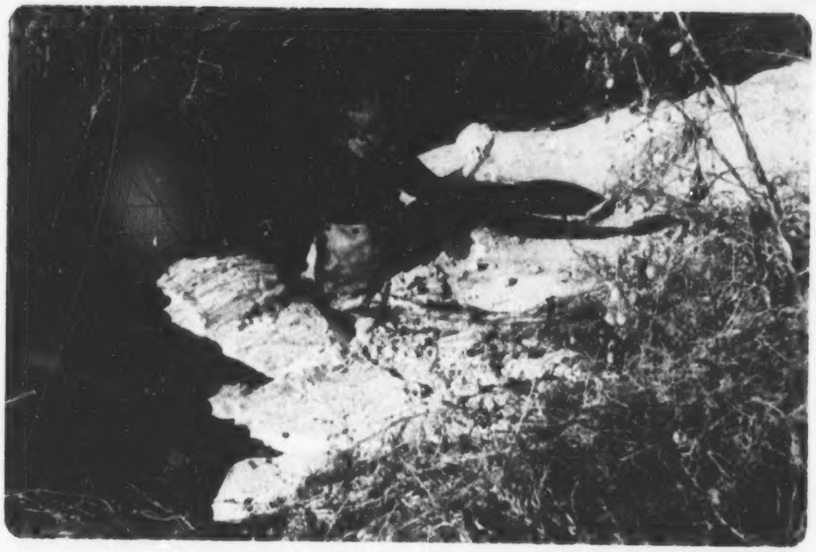


Figure 11

FOAM FROM CALCIUM CARBONATE WASTE POND ON WORM CREEK
North-South Town Road Two Miles Below Franklin County
Sugar Company. (Whitney, Idaho)

November 3, 1962, 3:00 PM

The Bear River, both above and below the State line, did not support a balanced benthos population because of the deposition of silt on the natural stream bed and fluctuating water levels.

During August only qualitative samples were collected from stations B-76.5 to 58.6 because of the sandy substrate. Mainly intolerant organisms such as caddisfly larvae and mayfly naiads were found at B-76.5. Their numbers were restricted because of the type of substrate.

During the fall survey large numbers of intolerant organisms were collected from artificial substrates showing that these organisms could survive if a suitable habitat was present. The Utah Department of Fish and Game on July 12, 1962, conducted a fish study at B-76.5 and collected walleye, sucker, carp, yellow perch, and bullhead. On November 5 a similar study was conducted and whitefish were captured. The stomachs of the whitefish were examined and found to contain midge fly larvae, black fly larvae, mayfly naiads and caddisfly larvae.

The biota at mile B-72.1 and B-68.5 was similar to B-76.5 in that a wide variety of organisms including many intolerant forms such as mayfly naiads and caddisfly larvae inhabited the artificial substrate. The bottom substrate at these stations was similar to the one above in that it was a fine sandy silt that covered all normal stream bottom. These stations remained relatively unchanged from the August survey to the November survey.

The biota, one mile below the Cub confluence (B-63.0), was almost identical to the upper stations during the summer. In the fall, however, there was an elimination of immature mayflies, and an increase in tolerant bloodworms. As indicated in Figure 7 the 132 organisms that inhabited the artificial substrate at B-63.0 were comparable in numbers to the 135 organisms found at B-76.5. Both substrate populations were less than the 247 found at B-72.1. Five species of benthos were found on the artificial substrate at B-63.0, below the confluence with the Cub River, compared to 6 and 13 species, respectively, at B-76.5 and B-72.1 above the Cub River confluence. Difficulty was encountered in removing the artificial substrate at B-76.5 and it is assumed that a number of organisms were lost in the removal process. Organisms that inhabited the artificial substrates were up to 20 times more numerous than those found in the stream environment.

Fish studies conducted at B-63.0 on August 1, 1962, revealed green sunfish, carp, sucker, yellow perch, bullhead and bass. Stomach analyses of these fish showed that the fish were feeding primarily on caddisfly larvae, mayfly naiads and midge fly larvae. Some of the individual stomachs contained as high as 15 caddisfly and mayfly larvae. A similar study was conducted on November 5, 1962, and only whitefish were collected. Analysis of the stomachs revealed that the fish were feeding on midge fly larvae, caddisfly larvae and black fly larvae.

Sphaerotilus was present at mile B-63 below the confluence of Cub River. This growth covered the few sticks and rocks that were present, thus reducing the living spaces for other organisms. The presence of _Sphaerotilus_ indicates that sugars and nitrogen are present in the water. It covers organisms (e.g., mayflies) and reduces the flow of water over their gills, thus causing their elimination because of a lack of oxygen.

The rapidity with which *Sphaerotilus* can cover a surface was demonstrated by the growth on the artificial substrate in the Bear River below Cub River confluence after 19 days. This indicates that the number of organisms probably would have been further reduced if the artificial substrate had been placed in the river for a longer period of time.

At mile B-58.6, below the Rocky Mountain Dairy outfall, there was also a reduction in intolerant forms such as mayflies and caddisflies from the summer to the fall. The environmental degradation at B-58.6 in the fall was not so severe as at B-63.0 in that all species of immature mayflies were not eliminated. *Sphaerotilus* was most evident at this station and covered the brush and bark. The substrate at this station, as well as B-63.0, was composed of fine sand. During the fall the pollution of the Bear River became more evident as it traveled downstream from B-57.5 to B-51.8. There was an elimination of intolerant organisms and a replacement with tolerant organisms. The brush and twigs in this entire stretch of stream was covered with *Sphaerotilus*.

Siltation

The major factor responsible for the reduction of benthic organisms in the lower Bear River is siltation. It has been stated* that in the years 1910 to 1950 "The Bear River has deposited about 10,000,000 tons of sandy sediment in its channel." This sand (0.1 to 1 mm. in diameter) has been evenly deposited five to six feet deep over the natural gravel, clay and silt bottom from Preston, Idaho, to Culter Reservoir. It comes from gullies, drained by Five Mile Creek and Deep Creek, developed as the result of improper agricultural practices and poor land management. The deposited sand is of an entirely different character and origin than that of the original river channel; it not only covers the original river bed, but also covers all but a few rocks along the river bank, thus further reducing available living spaces for organisms.

---

* Einstein, A. H., 1951. Preliminary Report on the Sedimentation in the Bear River Channel Between Cutler Dam and the Preston Bridge, Utah, to the Utah Power and Light Company, Salt Lake City. (Typed Copy)

Silt covers the gill filaments of fish with fine particles. If this coating is sufficiently thick and persists for a sufficient period of time the gas exchange between the blood and water will be reduced leading to death from anoxemia and carbon dioxide retention. The amount of silt that may directly affect fish depends on sediment type and size, environmental conditions, and variations in the fishes themselves.

The effects of sediment upon young fish, and especially eggs of trout, can be disastrous. Even moderate deposition is detrimental. Areas where silt has been deposited are often passed over by spawning fish in search of a clean gravel bottom; the fish that do spawn have their nests covered with inorganic sediment, thus reducing the production of young. The nests of trout are built in gravel. The eggs in the nest require a flow of water through the gravel for proper gas exchange. If silt settles between the stones, circulation of water is reduced resulting in an increase in the build-up of carbon dioxide which kills the eggs. As the young fish develop in the gravel, they are susceptible to silt which may cause serious inflammation of the gill membranes and eventual death.

The deposition of sediment also destroys fish food organisms. At Bear River mile 99.5 to 93.5 over 400 benthic organisms were found per square foot in contrast to the area of silt deposition (mile 89.5 - 51.8) where the only organisms were on the rocks near bridge abutments. Artificial substrates were placed in the reach and 250 organisms per square foot were established during periods of low siltation, which indicates that the major limiting factor in the Bear River from B-89.5 to 51.8 is the availability of living spaces for benthic forms.

The river bed above mile B-93.5 is composed of large stone and rubble. Such a bottom is stable, has an abundance of small interstices to provide shelter for bottom organisms, and presents a large surface for the growth of microscopic plants that are the basic food of most smaller aquatic organisms. Production of the food supply decreases as the particles become smaller than rubble size and is poorest in fine sand. Fine sand not only lacks suitable living areas, but also eliminates organisms through the abrasion of vital organs.

Since the majority of game fish feed on aquatic insects, the food supply is often the limiting factor in fish production. The examination of stomach samples from the Bear River fish indicates that the amount of food consumed was greater than the substrate supports. The source of additional food is most likely the drifting of organisms from above mile 93.5, thus the fish population is limited by available food supply.

The rate at which benthos drift downstream from a zone of concentrated production, such as a riffle, has been found by many investigators to be an important factor in supplying fish food. In a small Minnesota stream the maximum mean drift during the peak month of August for one species of mayfly approached 4.3 cc, (or roughly 10,000 individuals) per hour per foot of stream width. Drifting organisms were the source of the biota inhabiting the artificial substrates during the 19 days they were in the water.

Algae form the base of the aquatic food chain. Rubble has much area to support algae compared to sand that has very little usable area. Sediments destroy algae by limiting the light required for photosynthesis, by covering the bottom substrate, and through the breakdown of the cell walls by abrasion.

Summary of Biological Conditions

A biological survey conducted during July 28-August 2 and November 1-6, 1962, shows that:

1. The Cub River was biologically degraded by sewage and industrial wastes from mile 13.6 to its confluence with the Bear River; the fish population was altered from trout in the upstream reach to warm water species in the degraded section; benthos populations were likewise changed from those associated with clean water to those indicative of organically enriched water; slime growths were evident above the Idaho-Utah boundary, reappearing at downstream stations.
2. The East and West Branches of the Cub River Canal and Worm Creek were biologically degraded by sewage, industrial wastes and irrigation withdrawal and return water from Highway 91 (Preston, Idaho) to their confluence and/or termination.

3. The Bear River biota were affected by the deposition of sand and silt on the river bed below the confluence of Five Mile and Deep Creeks, by fluctuating water levels, and by organic enrichment below the confluence of Cub River; the fish population between Preston, Idaho, and Cutler Reservoir was apparently controlled by sediment deposition and by the aquatic insect population that was principally supplied by drifting organisms from upstream riffle areas; biological degradation below the confluence of the Cub River was demonstrated by a decrease in sensitive benthos and an increase in tolerant benthos, and the presence of *Sphaerotilus* downstream to Cutler Reservoir.

SUMMARY OF EXISTING POLLUTION

Upper Worm Creek

During both summer and fall Worm Creek and the West Branch of the Cub River Canal into which it flows are biologically degraded and contain bacterial densities in excess of desirable limits. These conditions become more pronounced at the termination of the irrigation season due to the reduction in flow of good quality dilution water from the Cub and Bear Rivers. Similar conditions are also found in the East Branch of the Cub River Canal at the State line. The major pollution source in this system is the Preston sewage treatment plant effluent.

Lower Worm Creek

Worm Creek from Whitney, Idaho, (W-6.5) to its confluence with the Cub River in Utah is severely polluted as a direct result of the October through November discharge of wastes by the Franklin County Sugar Company. This six mile interstate stretch of stream is little more than an open sewer during the beet sugar campaign, and as a result its flow is incapable of supporting any desirable aquatic life or serving any other useful purpose. Bacterial densities are very high, and chemical pollution parameters reach extreme levels. In addition large quantities of solid materials are deposited along the stream, particularly in an irrigation water impoundment, thereby diminishing its capacity and, ultimately, its useful life. It is aesthetically unpleasant by virtue of appearance and associated odors.

While this waste discharge occurs for just two months each year, the residual pollutional effects on Worm Creek and the Cub River can be observed throughout the year.

Cub River

The lower 14 miles of the Cub River lying in Idaho and Utah is polluted along its entire length, the severity of this pollution varying by location and time of year. Wastes discharged by the California Packing Company at Franklin, Idaho, causes biological degradation, excessive bacterial densities, and depletes and at times exhausts the oxygen resources of the river. These effects can be observed downstream in Utah. The polluted waters of the Cub River are also used for irrigation in both Idaho and Utah.

Upon entry of Worm Creek into the Cub River in Utah, the excessive pollution of this tributary, which originates in Idaho, causes serious pollution of the Cub River for the remaining 11 miles of its length. The organic waste load added by the Amalgamated Sugar Company doubles the biochemical oxygen demand of the stream and further compounds the polluted condition of the river. Additional pollution reaches the river as a result of the wastes discharged by the Pet Milk Company, six miles above its mouth.

Bear River

The biological productivity of the Bear River above Cutler Reservoir is greatly diminished by the addition of silt by Five Mile and Deep Creeks, which join the Bear in Idaho within ten miles of the State line. During the summer months the quality of water in the Bear River is affected only slightly under usual flow conditions by the entry of the Cub River. In October and November, however, the biochemical oxygen demand and bacterial numbers added by the Cub River increase these parameters in the Bear River beyond desirable limits. Biological degradation also occurs. The addition of wastes discharged by the Rocky Mountain Dairy produce no detectable changes in October and November when the river is already highly polluted. At other times, however, bacterial densities are noticeably increased in the river below this waste discharge.

PLAN FOR POLLUTION ABATEMENT

Abatement of the existing pollution of this interstate system of surface waters will require corrective action on the part of each of the six major waste discharges in the area. The complex nature of this system makes the precise definition of the extent of the required corrective action quite difficult. There are several more or less arbitrary approaches to this type of problem which could be applied. One example of this would be a requirement for an equal degree of treatment (per cent removal of pollutant) by all dischargers, the degree specified being that which would insure the maintenance of satisfactory standards of water quality. While such a procedure has at first glance the appearance of being a reasonable and equitable one, closer examination will show that it imposes an unreasonable burden on the smallest waste producer. Other similar schemes are possible and these have been considered for application in this case. It has been concluded that one of these as described below would be an equitable and easily applied plan for pollution abatement in the portion of the Bear River watershed under consideration here.

PRORATION OF AVAILABLE STREAM CAPACITY

The basis for this plan is that each discharger would be required even in the absence of all other dischargers to provide a certain minimum degree of treatment which would be determined in each case by the appropriate water quality standards and the dilution stream flow available. By applying this degree of treatment each individual discharger would, in the absence of other waste sources, be adequately protecting the stream with respect to his own discharge. However, where there is more than one discharger on the system, as in this case where there are six, this minimum degree of treatment by each is no longer sufficient, since the individual discharges are superimposed on the stream with the result that stream quality standards are exceeded. As a result, each discharger must provide an added increment of treatment to compensate for the presence of the other discharges.

It is proposed that the baseline permissible waste discharge for each waste source in the absence of the others be first determined. It is further proposed that the increment of this permissible waste discharge, which must be removed because of the presence of all six dischargers on the system be determined on the basis that this increment shall be the same percentage of the baseline discharge for all of the waste sources involved.

The stream water quality standards that will be applied are those of the State of Utah. These standards are given in the Appendix and are subdivided according to various stream classifications. The streams in the system under consideration have been classified by the Utah State Pollution Control Board by amended Order* of November 23, 1960, as follows:

---

* The full text of this Order may be found in Appendix "A"

Bear River from Utah-Idaho State Line to Cutler Dam	Class C
Cub River from Utah-Idaho State Line to Confluence with Worm Creek	Class C
Cub River from Confluence with Worm Creek to Mouth	Class D
Worm Creek from Utah-Idaho State Line to Confluence with Cub River	Class D

All canals located in whole or in part in the State of Utah whose source of water is the Bear River or its tributaries shall bear the classification required of the water at point of diversion

In selecting the stream flows to be used in calculations of the available receiving water dilution capacity, consideration will be given to minimum flow conditions during the period of discharge. Obviously, if waste treatment capacity is sufficient to protect the stream during minimum flow periods, it will be adequate at all other times as well. Furthermore, since the minimum stream flow condition will vary in severity from year to year, some consideration must be given to the drought return period which will be used for design purposes. It is common in sanitary engineering practice to use the minimum monthly flow that will be exceeded in 9 years out of 10. The design flow used herein, therefore, is the minimum monthly average flow that can be expected once in 10 years. This flow has been determined by performing a drought frequency analysis (Gumbel plot) of available U. S. Geological Survey records for gage stations on the streams in question. The once in 5-year minimum monthly average flow was also determined, but did not differ to a significant degree from the once in 10-year flows used in the succeeding calculations.

The maximum permissible waste discharge has been calculated so as to insure that one of the stream standards, that referring to average biochemical oxygen demand (BOD_5) concentration, is met. If this stream standard is adhered to, it is likely, though not certain, that other applicable standards (bacteriological, suspended and floating solids, etc.) will be met as well. If in meeting the BOD_5 standard other applicable standards are not also met, additional treatment measures will need to be applied.

Table 8 gives the maximum permissible discharge for each waste source that, under the minimum flow conditions cited, will result in not exceeding the applicable stream standard (BOD_5) anywhere in the system. This determination has been made for two time periods; the summer irrigation season and the October-November sugar beet campaign.

The system of calculations used to determine the combined permissible discharges shown in Table 8 is described in Appendix B. In carrying out these calculations the appropriate stream standards (BOD_5) have been reduced in each case by 2 ppm, which is slightly higher than the amount that would normally be expected to be already present in the streams from natural sources. The stream flows used in each case are the once in 10-year minimum monthly average flows obtained from analysis of stream flow records of past years where such records were available. For streams where adequate records do not exist, the flows observed during the field surveys were used.

In order to carry out the calculations shown in Appendix B, it is necessary to have information on the decay rate, K_1, of waste materials

MAXIMUM PERMISSIBLE WASTE DISCHARGES - BEAR RIVER SYSTEM

Table 8

Waste Source	Receiving Stream	Stream Classifications	Dilution Flow Available (cfs)	Baseline Maximum Discharge (Lbs.BOD$_5$ Per Day)	Combined Permissible Discharge Lbs.BOD$_5$ Per Day)
Summer					
Preston Sewage Treatment Plant	West Branch Cub River Canal	C	24	390	390
California Packing Corp. (Franklin)	Cub River	C	2	32	32
Pet Milk Co. (Richmond)	Cub River	D	20	2,480	2,480
Rocky Mountain Dairy (Smithfield)	Bear River	C	255	4,130	4,130
Fall					
Preston Sewage Treatment Plant	West Branch Cub River Canal	C	7	115	115
California Packing Corp. (Franklin)	Cub River	C	2.7	45	25
Franklin County Sugar Co.	Worm Creek	D	10.5	1,310	750
Amalgamated Sugar	Cub River	D	13.2	1,640	950
Pet Milk Co.	Cub River	D	33.2	4,120	2,340
Rocky Mountain Dairy	Bear River	C	333	5,400	3,080

(BOD_5) in the stream. Also required is knowledge of the time of passage in each stretch of the various streams involved at the minimum flows selected for analysis. This information was obtained from data collected during surveys carried out during the summer and fall. BOD_5 decay rates for each stretch of stream were obtained from analysis of time series samples. Dye tracers were employed to measure the time of passage between stream stations at the flows then occurring. Procedures for estimating time of passage at other flows as well as a summary of deoxygenation rate data are presented in Appendix C.

In Table 8 the column titled Baseline Maximum Permissible Discharge is the amount of BOD_5 which could be discharged by each waste source (assuming all others were absent) without exceeding stream standards at the point of discharge. The last column, Combined Maximum Permissible Discharge, is the amount of BOD_5 which may be simultaneously discharged by each waste source without exceeding stream standards at any point in the system. The amount shown in this second column for a given waste source will be smaller than the amount in the Baseline column where two or more discharges produce an additive effect on pollutant concentrations in the stream.

In the case of the Preston Sewage Treatment Plant, the receiving waters in both critical periods, summer and fall, are those of the West Branch of the Cub River Canal. Since none of the other waste sources discharge to these waters no reduction in the Baseline discharge is necessary in this case. During the summer period, in fact, no reduction beyond the Baseline discharge were found to be necessary for any of the waste sources. In other words, if each waste discharge (in the absence of others) meets stream standards at the point of its discharge, standards will be met throughout the system (after combination of all loads) without further reduction in waste quantities. In the fall, however, this is not the case. The wastes from the cannery and the two beet sugar mills combine in the Cub River in Utah, and, therefore, meeting stream standards at the point of discharge is not sufficient to protect the entire system. It was found by the calculations described in Appendix B that if the baseline discharge of each of these waste sources were reduced by 43% from their original values, the selected standard would be met throughout the system. This percentage when applied to each of the baseline discharges results in the figures in the combined discharge column for the fall period.

Table 9 compares the amount of organic waste material (BOD_5) actually found to be entering the streams during the field surveys with the permissible discharge values calculated above. During the summer the Preston Sewage Treatment Plant effluent was found to exceed the calculated permissible discharge slightly, while during the fall it was almost five times greater. This is caused by the large reduction in flow in the West Branch following the termination of the irrigation season. Effluents from the cannery and the beet sugar mills were found to be greatly in excess of the calculated permissible discharges. Further waste reductions of 98% and 96% are required at the Franklin County and Amalgamated mills, respectively. The cannery at Franklin, Idaho, must reduce their present waste discharge during the summer by 97% and during the fall by 96% in order to protect the Cub River. The observed waste quantities discharged

OBSERVED VS. PERMISSIBLE WASTE DISCHARGES (Lbs. BOD_5 Per Day)

Table 9

	Summer		Fall	
Waste Source	Observed Discharge	Permissible Discharge	Observed Discharge	Permissible Discharge
Preston Sewage Treatment Plant	450	390	545	115
Franklin County Sugar Co.	-	-	33,300	750
California Packing Co.	1,020	32	580	25
Amalgamated Sugar Co.	-	-	21,685	950
Pet Milk Co.	138	2,480	226	2,340
Rocky Mountain Dairy	1,320	4,130	400	3,080

by the two dairies in Utah as shown in Table 9 are both much less than the calculated permissible discharge levels. Thus, while for the single pollutant considered, ie. BOD_5, existing stream dilution capacity is sufficient to assimilate the wastes produced by these two industries, this should not be interpreted to mean that no treatment is required. The bacterial stream standards must also be met and to accomplish this, some corrective action would be required. In addition to the increase in stream bacterial densities directly attributable to the bacterial content of the waste effluent itself, stimulating effects of these dairy effluents upon stream bacterial densities could be expected and have been observed in the field surveys. This is related to the organic enrichment brought about in the stream as a result of the entry of such effluents. It is suggested that the appropriate type and degree of treatment in the case of these two dairies be determined by the State of Utah, inasmuch as a prorating of the waste assimilative capacity of interstate waters is not primarily involved.

It would appear from Table 9 in comparing the observed and permissible discharges for the two dairies that a significant amount of stream assimilative capacity is remaining unused at the expense of the other waste producers. This occurs because of the poor distribution, from the standpoint of waste disposal, of the available stream flows in the basin. It may be noted from Table 8, for example, that the dilution flow available in the Cub River is 150% greater at the Pet Milk Co. discharge point than at the Amalgamated Sugar Co. discharge location. This is due to the ground water accretions occurring between these two locations, as has been described earlier. The Rocky Mountain Dairy permissible discharge is determined by its more favorable location on the Bear River where larger stream flows are available. The critical location in the system, ie. where the stream pollutant concentration will be greatest under the proposed plan, is at the point of waste discharge of the Amalgamated Sugar Co. where these higher flows are not available.

The proposed proration of available stream waste assimilative capacity leaves little margin in some locations for waste disposal by new industires that may locate in this area in the future. This could present problems, particularly if an industry were to locate along the Cub River or Worm Creek in the area north of Lewiston, Utah. Because of the extremely limited capacity available in this system, however, a reserve for new industry has not been included. In the event additional waste sources would locate in the critical areas of this basin, the plan proposed could be easily revised to include them at the expense of slightly increased treatment requirements for the existing sources.

FEASIBILITY OF PROPOSED PLAN

The required levels of waste reduction indicated for the Preston Sewage Treatment Plant could be accomplished with little difficulty by the addition of commonly employed secondary treatment units. Provision of secondary treatment together with adequate chlorination would result in the elimination of the objectionable conditions noted in the West Branch Canal and would meet desired water quality objectives in Utah. Required waste reduction for the cannery and the sugar mills could conceivably be achieved by a combination of in-plant process changes, waste treatment and waste storage. Storage, of course, may not be considered as an ultimate method of disposal unless annual losses by evaporation and seepage exceed the rate of input. In view of the waste volumes produced by these industries only a very slight percentage could be expected to be lost in that manner. Essentially all of the waste volume produced, therefore, must ultimately be discharged to the basin's streams in order to have the storage capacity available when it is needed again during subsequent periods of waste production.

The total amount of waste material (BOD_5) that would be stored at the end of the sugar beet campaign can be estimated from past studies.* This work indicates that in extremely cold climates slightly more than 50% of the BOD_5 load added to ponds will be removed during the filling period of the campaign. This reduction occurs very soon after the wastes are added to the lagoon and apparently results from the initial rapid settling of the suspended material in the raw waste. Little subsequent reduction in BOD_5 following the end of the campaign was noted during the winter period of heavy ice cover on the ponds. The wastes studied in this case excluded the lime cake slurry, the BOD_5 of which is largely (85%) in settleable form.

---

* "Report on Disposal of Beet Sugar Wastes by the Lagoon Method at the American Crystal Sugar Co., Moorhead, Minn. 1949, 1950, and 1951," Minnesota Dept. of Health. (Mimeographed)

On the basis of these findings, it is estimated that if all wastes produced by the Franklin County Sugar Co. were stored in lagoons, a total of 999,000 pounds of BOD_5 would remain to be discharged at the end of the winter period of ice cover following the sugar beet campaign. This figure excludes the barometric condenser waste water, which it has been assumed has been discharged directly to the stream during the campaign. This total was arrived at as follows:

$$\underset{\text{(lbs./day BOD}_5\text{ produced)}}{33{,}300} \times \underset{\text{(campaign days)}}{60} \times \underset{\text{(fraction removed)}}{0.5} = 999{,}000 \text{ lbs.}$$

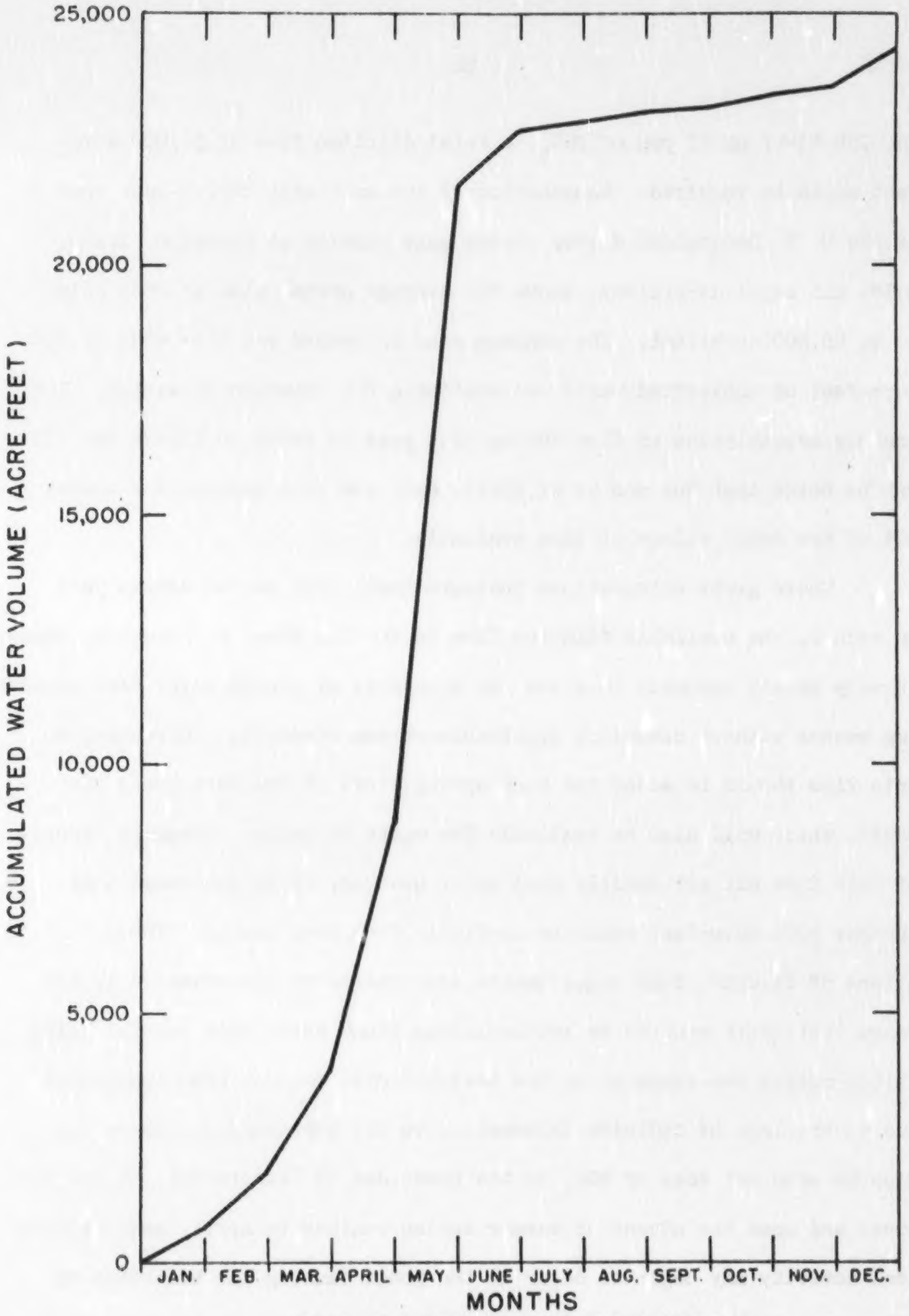
Similarly, a total residual waste volume of 1,140,000 pounds of BOD_5 has been calculated for the Amalgamated Sugar Co. at Lewiston, as follows:

$$\underset{\text{(lbs./day BOD}_5\text{)}}{38{,}000} \times \underset{\text{(campaign days)}}{60} \times \underset{\text{(fraction removed)}}{0.5} = 1{,}140{,}000 \text{ lbs.}$$

The waste addition to the Lewiston ponds includes the pulp silo drainage presently discharged to the Cub River and wastes contained in the flume water, screen water, and lime pond overflow. Barometric condenser water is assumed to be discharged directly to the stream and the Steffen's wastes to a solar evaporation pond as is presently practiced. The 20% greater beet processing rate at the Lewiston plant results in a comparable increase in the waste production as shown above.

The quantity of BOD_5 remaining in storage at the end of the campaign at both mills totals 2.1 million pounds. In order to discharge this quantity of waste without exceeding the Class D standard for Worm Creek and the Cub River of 25 ppm of BOD_5, a total dilution flow of 31,000 acre-feet would be required. Examination of the available twelve-year record of the U. S. Geological Survey stream gage station at Franklin, Idaho, below all major diversions, shows the average annual flow at that point to be 46,800 acre-feet. The minimum year of record was 1941 when 24,300 acre-feet of undiverted water was available for dilution of wastes. The monthly accumulation of flow during that year is shown in Figure 12. It can be noted that the months of April, May, and June account for almost 80% of the total volume of flow available.

These gross calculations indicate that, even in the driest year on record, the available dilution flow in the Cub River at Franklin, Idaho, is very nearly adequate to allow the discharge of stored sugar beet processing wastes without exceeding applicable stream standards. Moreover, to this flow should be added the high spring flows of the Worm Creek subbasin, which will also be available for waste dilution. Adequate records of this flow are not readily available; however, it is estimated that another 5000 acre-feet would be available from this source. These calculations of dilution flow requirements are considered conservative in the sense that waste removal by recirculating flume water over the trickling filter during the campaign at the Lewiston mill has not been considered due to the lack of definite information on its performance. There may also be some net loss of BOD_5 in the ponds due to "freeze-out" in the ice cover and upon the advent of warmer spring weather in April, some biochemical activity may begin to occur in the ponds causing the breakdown of BOD_5. Finally, the Lewiston plant has the capability of utilizing their



CUB RIVER NEAR FRANKLIN
MINIMUM YEAR OF RECORD (1941)

FIGURE 12

trickling filter for treatment of the pond contents before their discharge to the Cub River in the spring. The degree of success possible with this latter procedure remains to be determined, however. Although the waste production of the Franklin, Idaho, cannery has not been included in the above calculations, it is quite small as compared to the sugar beet wastes and its inclusion in the total waste volumes requiring dilution would not significantly affect the conclusions reached.

Of course, consideration must be given to the storage volumes required to utilize the spring dilution flow available in this watershed. The Franklin County Sugar Company flow was found during the fall survey to average 10.3 cfs. Over a 60-day period a total waste volume of 1,200 acre-feet would be produced at this flow rate. However, by simply segregating the barometric condenser water, which has a relatively low BOD_5 content, and discharging it directly to Worm Creek, the total waste volume would be reduced by approximately 40% to 720 acre-feet. If a system for recirculation and reuse of flume water was installed at the Franklin Company plant, as it has been at the Lewiston, Utah, plant, water consumption would be reduced by about 50%, and the required waste storage volume would be further lowered to approximately 120 acre-feet. Such a storage requirement is not considered an unreasonable one for this type of industrial waste problem. The Lewiston mill, for example, presently has available a waste storage volume in excess of this amount.

Although the Franklin County Sugar Company is not located on the Cub River, the high spring flows of Worm Creek could be utilized for waste dilution and this flow could be supplemented by transfer of Cub River water to the Worm Creek Basin via the Cub River Canal. This canal is not used for transfer of irrigation water until mid-May (see Figure 1) and its capacity, which is in excess of 150 cfs, would undoubtedly be available for use by the sugar mill prior to that time.

Thus, while the stream pollution assimilative capacity of this basin is low as compared to the large quantities of wastes produced, and the stream flow available for dilution is poorly distributed in time from the standpoint of waste disposal, there is, nevertheless, sufficient dilution stream flow available on an annual basis that may be utilized in conjunction with reasonable treatment steps to satisfactorily protect the interstate surface waters of the area without placing unreasonable burdens upon the waste producers involved.

In order to provide needed information on stream flow rates, the U. S. Geological Survey was requested by the Public Health Service to install gaging stations at nine different locations in this area. Several of these permanent type stations, especially those on Worm Creek and the Cub River, could be used to good advantage by the beet sugar industries in tailoring their waste discharge rates to the variable daily flow of dilution water in nearby streams. The judicious utilization of available dilution flows in this manner would help to insure that stream standards would be maintained during the waste discharge period and that all stored wastes could be satisfactorily discharged prior to the next beet sugar campaign.

BEAR RIVER SILTATION

It has previously been noted that one of the most damaging pollution conditions encountered in the area under study is the heavy siltation which has taken place over the years in the Bear River from just above the State line to the Cutler Reservoir. The source of this silt has been identified as the drainage areas of Five Mile and Deep Creeks, which join the Bear River in Idaho within ten miles of the State line. In addition to damages to the biological productivity of the stream as noted herein, this siltation is reported* to be the cause of flooding of valley bottom lands and to have adverse effects on the operation of the Cutler power plant and reservoir. The land from which this silt is being washed is also damaged by this process of evasion.

This silt " . . . seems to originate from the large number of smaller and larger sized gullies, such as Five Mile Creek, which have developed within historic time as a consequence of improper agricultural practices, of road ditches, cow paths, section lines, increased ground water drainage from irrigation and other interference of man with the natural runoff pattern."* Elimination of the continued erosion of these areas by the employment of appropriate land and watercourse management practices by landowners and responsibly governmental agencies may offer hope for eventual restoration of the Bear River to former condition as a productive and useful watercourse.

---

* loc. cit. pg. 55

CONCLUSIONS

1. Pollution of interstate waters continues to exist:
   a. in the West Branch of the Cub River Canal due to wastes discharged by the Preston, Idaho, Municipal Sewage Treatment Plant;
   b. in Worm Creek due to wastes discharged by the Franklin County Sugar Company (Whitney, Idaho);
   c. in the Cub River at the State line due to wastes discharged by the California Packing Corporation (Franklin, Idaho);
   d. in the Cub River below Worm Creek due to the waste discharges of b) and c) above, and those of the Amalgamated Sugar Company (Lewiston, Utah) and the Pet Milk Company (Richmond, Utah);
   e. in the Bear River below the mouth of the Cub River due to the waste discharges in b), c), and d) above, and to the waste discharge of the Rocky Mountain Dairy (Smithfield, Utah).
   f. in the Bear River from just above the State line to Cutler Reservoir, due to the heavy deposition of silt which originates in Idaho.

2. Abatement of this pollution could be achieved by:
   a. the installation of secondary treatment and adequate chlorination at the Preston, Idaho, Municipal Sewage Treatment Plant;

b. reduction in the organic waste load (BOD_5) discharged by the Franklin County Sugar Company, the California Packing Corporation, and the Amalgamated Sugar Company to the levels shown in Table 8. Such reductions would result in an equitable distribution of the existing assimilation capacity among these waste sources that would meet a critical water quality objective (BOD_5) in the streams of the system. The required reductions in waste quantities, although quite large, can be achieved by a combination of in-plant process changes, waste treatment and waste storage for subsequent release during periods of high stream flow;

c. The application of appropriate land management practices in the area of origin of the eroded silt being discharged to the Bear River.

3. The waste discharge reductions mentioned above will insure that a selected water quality parameter, i.e., BOD_5 will meet desired stream standards. While this does not insure that other pertinent stream standards will also be met, it is considered likely that they would be. In the event this assumption is not realized, additional corrective action would need to be considered.

4. The organic waste loads (BOD_5) discharged by the two dairies in Utah do not raise the BOD_5 content of the receiving waters to a significant degree as compared to stream standards. However, based on field survey findings, it is believed that effluents are capable of exerting a stimulatory effect on stream bacterial densities. It is suggested that these industires obtain and follow the recommendations of the Utah State Department of Health regarding necessary treatment requirements.

APPENDICES

APPENDIX "A"

BEFORE THE STATE WATER POLLUTION CONTROL BOARD
STATE OF UTAH

In the Matter of Adopting) Water Classifications for) Those Portions of Bear) River and Its Tributaries) Located in Utah)	**AMENDED ORDER**

Be it known that on the 23rd day of November 1960, in the Sky Room of the Student Union on the Campus of Utah State University, Logan, Utah, and pursuant to the provisions of Section 73-14-6, Utah Code Annotated, 1953, as amended, a hearing was held in the matter of adopting water classifications for those portions of Bear River and its tributaries located in the State of Utah; and due and lawful notice of said hearing having been first given and the matter having been fully considered,

NOW, THEREFORE, it is hereby ordered that the following classifications shall be applied to the waters aforementioned, in accordance with "The Standards of Quality and the Regulations for Water Classification," adopted by the Water Pollution Control Board November 9, 1954, and amended September 7, 1960.

Bear River from Utah-Idaho State Line to Cutler Dam	Class C
Bear River from Cutler Dam to confluence with Malad River	Class C_1

Bear River from confluence with Malad River to Mouth	Class D_1
Cub River from Utah-Idaho State Line to confluence with Worm Creek	Class C
Cub River from confluence with Worm Creek to Mouth	Class D
Worm Creek from Utah-Idaho State Line to confluence with Cub River	Class D
Maled River from Utah-Idaho State Line to waste outfall of Garland Plant of Utah-Idaho Sugar Co.	Class C_1
Malad River from waste outfall of Garland Plant of Utah-Idaho Sugar Co. to Mouth	Class D_1
All other portions of and tributaries to Bear River in Utah	Class C

All canals located in whole or in part in the State of Utah whose source of water is the Bear River or its tributaries shall bear the classification required of the water at point of diversion.

It is further ordered, pursuant to the provisions of Section 73-14-6, Utah Code Annotated, 1953, as amended, that each person, body politic or corporate, partnership, association, or company, discharging any wastes into any of the waters herein classified shall proceed with diligence to alter such discharge or discharges by construction of approved treatment facilities or other approved manner, to the extent necessary for compliance with the requirements of the stated classifications, and that said alteration of all waste discharges referred to shall become fully effective not later than January 1, 1963.

/s/ William F. Sigler, Chairman
State Water Pollution Control Board

Attest:

/s/ Lynn M. Thatcher
Executive Secretary

UTAH WATER POLLUTION CONTROL BOARD

THE STANDARDS OF QUALITY AND THE REGULATIONS FOR WATER CLASSIFICATION

Adopted by the Utah Water Pollution Control Board, November 19, 1954, and made official by order of the Board, February 24, 1955, pursuant to authority of Section 73-14-6, Utah Code Annotated, 1953, as amended, by Session Laws of 1953. Amended by order of the Board, September 7, 1960.

CLASS "A" WATERS

Class "A" waters shall be so protected against pollution as to be suitable at all times without treatment for domestic water supplies, irrigation, stock watering, fish and wildlife propagation, recreation, as a source for industrial supplies, and for other uses as may be determined by the Board.

Regulations and Standards: No person shall discharge any wastes directly into Class "A" waters, or dispose of any wastes in such a way as to result in

(1) characteristics of said waters exceeding the limits prescribed by U. S. Public Health Service Drinking Water Standards as of February 6, 1946, or

(2) chemical characteristics of said waters exceeding the recommendations for irrigation water quality as outlined in Chapter 5 of the U. S. Department of Agriculture "Agriculture Handbook No. 60," issued February 1954.

CLASS "B" WATERS

Class "B" waters shall be so protected against pollution as to be suitable at all times for domestic supplies which are treated before use by disinfection only. Class "B" waters shall be suitable without treatment for irrigation, stock watering, fish and wildlife propagation, recreation, as a source for industrial supplies, and for other uses as may be determined by the Board.

Regulations and Standards: No person shall discharge any wastes directly into Class "B" waters or dispose of any wastes in such a way as to result in

(1) physical and chemical characteristics of said waters exceeding the limits prescribed by U. S. Public Health Service Drinking Water Standards as of February 6, 1946, or

(2) chemical characteristics of said waters exceeding the recommendations for irrigation water quality as outlined in Chapter 5 of the U. S. Department of Agriculture "Agriculture Handbook No. 60," issued February 1954, or

(3) a monthly arithmetical average "most probable number" (MPN) of coliform organisms in said waters exceeding 50 per 100 milliliters; or in an MPN exceeding this number in more than 20% of the samples collected during any month; or in an MPN exceeding 100 per 100 milliliters in more than 5% of such samples.

CLASS "C" WATERS

Class "C" waters shall be so protected against pollution as to be suitable at all times for domestic water supplies which are treated before use by coagulation, sedimentation, filtration, and disinfection. Class "C" waters shall be suitable without treatment for irrigation, stock watering, fish and wildlife propagation, recreation (except swimming), as a source for industrial supplies, and for other uses, as may be determined by the Board.

Regulations and Standards: No person shall discharge into Class "C" waters any wastes

(1) which result in chemical characteristics of said waters exceeding the limits prescribed by U. S. Public Health Service Drinking Water Standards as of February 6, 1946, or

(2) which result in chemical characteristics of said waters exceeding the recommendations for irrigation water quality as outlined in Chapter 5 of the U. S. Department of Agriculture "Agriculture Handbook No. 60," issued February 1954, or

(3) which result in a monthly arithmetical average "most probable number" (MPN) of coliform organisms in said waters exceeding 5,000 per 100 milliliters; or in an MPN exceeding this number in more than 20% of the samples collected during any month; or in an MPX exceeding 20,000 per 100 milliliters in more than 5% of such samples, or

(4) which result in a monthly arithmetical average biochemical oxygen demand (BOD) in said waters exceeding five parts per million (ppm); or in a BOD exceeding this amount in more than 20% of the samples collected in any month; or in a BOD exceeding 10 ppm in more than 5% of such samples, or

(5) which result in any slicks, floating solids, suspended solids or sludge deposits in said waters which are readily visible, or which result in an appreciable change in color of said waters, or

(6) which result in a pH of said waters lower than 5.0 or greater than 9.0, or

(7) which contain any toxic wastes, phenols, or other deleterious substances in such concentrations or at such temperatures as will render said waters injurious to fish life and waterfowl, or unsafe or unsuitable as sources of water supply for domestic use, food processing or industrial use, or unsuitable for agricultural purposes, stock watering, or recreation (except swimming).

CLASS "D" WATERS

Class "D" waters shall be so protected against pollution as to be suitable at all times for general irrigation, but not for irrigation of lawns, recreational areas, pastures used for dairy cattle, root crops or any low growing crops produced for human consumption. Such waters shall be suitable also as a source for industrial supplies and for other uses as may be determined by the Board.

Regulations and Standards: No person shall discharge into Class "D" waters any wastes

(1) which result in chemical characteristics of said waters exceeding the limits prescribed by U. S. Public Health Service Drinking Water Standards as of February 6, 1946, or

(2) which result in chemical characteristics of said waters exceeding the recommendations for irrigation water quality as outlined in Chapter 5 of U. S. Department of Agriculture "Agriculture Handbook No. 60," issued February 1954, or

(3) which result in a monthly arithmetical average "most probable number" (MPN) of coliform organisms in said waters exceeding 5,000 per 100 milliliters; or in an MPN exceeding this number in more than 20% of samples collected during any month; or in an MPN exceeding 20,000 per 100 milliliters in more than 5% of such samples, or

(4) which result in a monthly arithmetical average biochemical oxygen demand (BOD) in said waters exceeding 25 parts per million (ppm); or in a BOD exceeding this amount in more than 20% of the semples collected in any month; or in a BOD exceeding 50 ppm in more than 5% of such samples, or

(5) which result in any slicks, floating solids, suspended solids, or sludge deposits in said waters which are readily visible, or which result in an appreciable change in color of said waters, or

(6) which result in a pH of said waters lower than 5.0 or greater than 9.0, or

(7) which contain any toxic wastes, phenols, or other deleterious substances in such concentrations or at such temperatures as will render said waters unsuitable for the uses designated in the introductory paragraph of this section.

CLASS "E" WATERS

Class "E" waters shall be protected against such pollution as may result in nuisances. They shall have no beneficial uses.

Regulations and Standards: No person shall discharge into Class "E" waters any wastes which will create a condition constituting or resulting in a nuisance. The Board may direct that such waters be suitably isolated by closed conduit, approved fencing, or other means.

The following notes were adopted as modifications to The Standards of Quality and The Regulations for Water Classification on September 7, 1960, and are hereby made a part of said Standards and Regulations.

NOTE 1: The Board may assign any one of the foregoing classifications to a given water notwithstanding the presence in said water of natural pollutants in excess of limits established by the classification, in which case the subscript "1" shall be added to the usual classification designation (A_1, B_1, C_1, etc.) to denote the modification of water quality. No change in waste discharge restrictions of the basic classification shall be inferred, except that the discharge of any wastes in such a way as to increase the concentration of any of the excessive natural pollutants in the classified water is prohibited.

NOTE 2: Wastes discharged to waters of the State under limitations imposed by a given classification shall be further controlled as required to protect water quality designated by all downstream classifications.

APPENDIX "B"

RIVER BASIN ANALYSIS
TO DETERMINE DISCHARGE REQUIREMENTS

Given the system shown in Figure B-1, find equitable treatment levels for each waste discharge.

Operating Policy - Each waste discharge is required to provide a certain minimum degree of treatment to meet appropriate stream standards even if no other pollution sources were present. Determine this treatment level for each discharger and then increment each upward equally so that appropriate stream standards are met throughout the system. Consider the non-conservative pollutant, BOD.

Definition of terms:

i = stream stretch

s_i = stream standard (concentration) in i th stretch

q_i = stream flow in i th stretch

c_i = pollutant concentration, head of i th stretch

K_i = $10^{-k_i t_i}$ decay of pollutant in i th stretch

E_j = permissible pollutant discharge by j th source in absence of other pollution p = fraction of E_j which may be discharged considering residual pollutant flow from upstream sources.

Find p

Starting with the stretch farthest downstream,

(1) $i = 9$

$$pE_e + q_8C_8K_8 \leq q_9s_9$$

(2) $i = 8$

$$q_7C_7K_7 \leq q_8s_8$$

(3) $i = 7$

$$pE_d + q_6C_6K_6 \leq q_7s_7$$

(4) $i = 6$

$$pE_c + q_4C_4K_4K_5 + q_2C_2K_2K_5 \leq q_6s_6$$

(5) $i = 5$

$$pE_aK_2 + pE_bK_4 \leq q_5s_5$$

Now in Equation (1) the unknowns are p and q_8C_8, the total pollutant flow at the head of stretch 8. But,

$$q_8C_8 = pE_aK_2K_5K_6K_7 + pE_bK_4K_5K_6K_7 + pE_cK_6K_7 + pE_dK_7$$

Substituting this expression in Equation (1) we find:

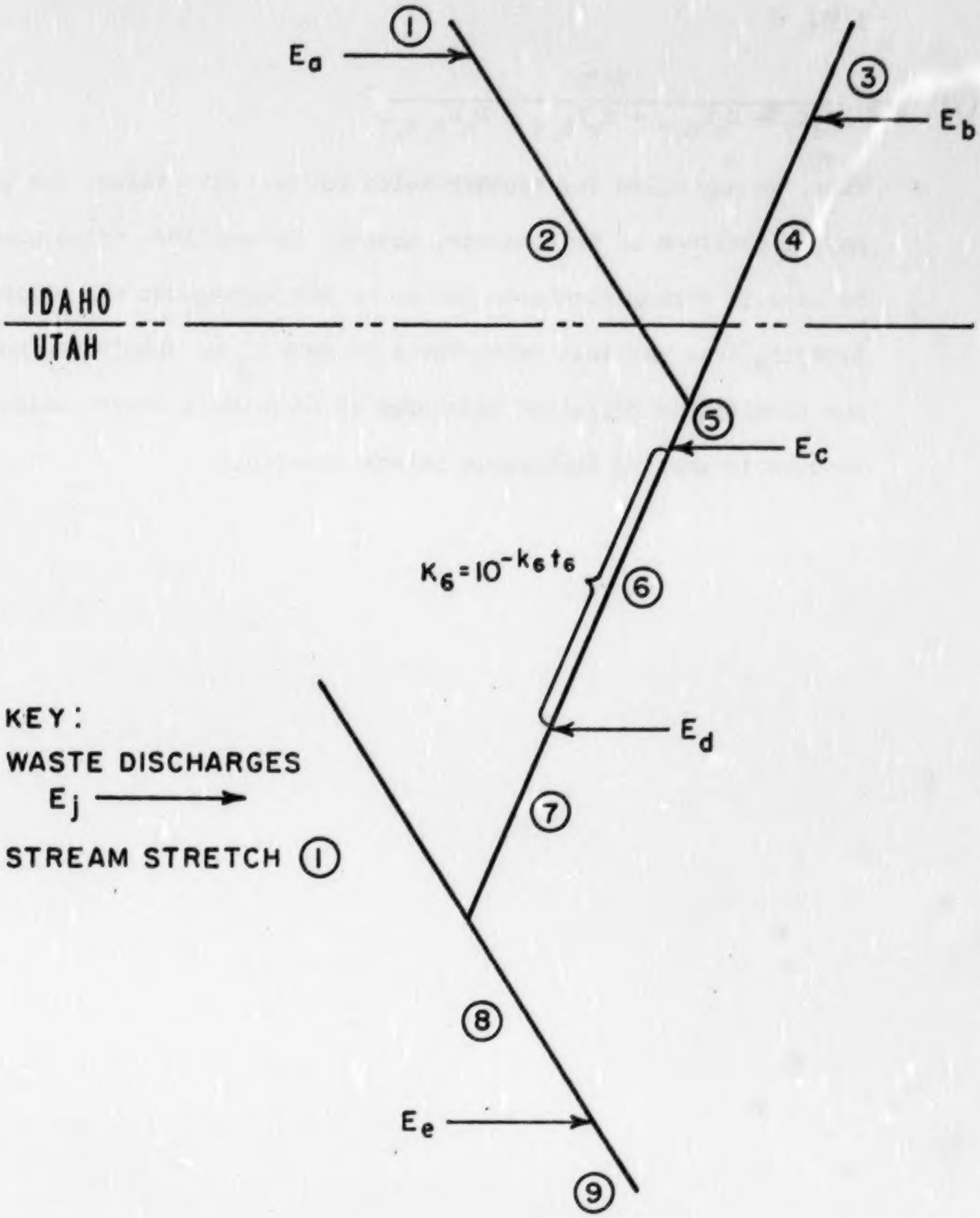
$$(6) \quad p \leq \frac{q_9s_9}{E_e + E_aK_{2,5,6,7,8} + E_bK_{4,5,6,7,8} + E_cK_{6,7,8} + E_dK_{7,8}}$$

Since we wish to maximize p, we change Equation (7) to an equality and solve for p. The value for p thus obtained insures that the stream standard is met at i = 9, but does not insure that it is met at any other point. However, in an analogous manner for

$i = 8$

$$(7) \quad p \leq \frac{q_8 s_8}{E_d K_7 + E_c K_{6,7} + E_b K_{4,5} + E_a K_{2,5,7}}$$

Thus, we may solve for another value for p. Five values for p may be obtained in this manner, however the smallest value must be used if stream standards are to be met throughout the basin. Applying this smallest value for p to each E_j we obtain the maximum permissible pollutant discharge by each waste source which results in meeting applicable stream standards.


①
E_a
③
E_b
②
④
IDAHO
UTAH
⑤
E_c
$K_6 = 10^{-k_6 t_6}$
⑥
E_d
KEY:
WASTE DISCHARGES
E_j
STREAM STRETCH ①
⑦
⑧
E_e
⑨

SCHEMATIC FLOW DIAGRAM
BEAR RIVER SYSTEM
FIGURE B-1

APPENDIX "C"

TIME OF PASSAGE AND DEOXYGENATION RATE DATA

TIME OF PASSAGE

Since the rate of disappearance of BOD_5 in a stream is a time dependent biochemical reaction, it is necessary that reasonably accurate estimates of the time of passage between river stations be possible for prediction purposes. In this survey a relatively new technique was used to measure time of passage. A fluorescent dye tracer was introduced into the river to "tag" a given mass of water. At a downstream station water was continuously pumped from the river through a detection instrument (GK Turner Fluorometer) which measured the amount of dye present to a lower limit of sensitivity of 0.1 parts per billion. The measured dye concentration is continuously recorded, providing a permanent record of the passage of dye at the downstream station. This procedure was carried out for each stream stretch between the sampling stations shown in Figure 1. The information obtained by these tests served as a check upon the reliability of the estimating procedure which is described below.

The U. S. Geological Survey provided rating curves and cross-sections of the streams in the area where gaging stations are located.

This information was used to develop equations of the type:

$$v = aQ^b \tag{1}$$

where v is the mean stream velocity (fps) and Q is the stream flow (cfs). The constants a and b may be determined from a plot of the data after a logarithmic transformation of Equation (1). Cross-section measurements were also made at many points on the streams between the gaging stations. By using the constant b from the nearest stream gage or an average of the b values obtained at gages above and below the cross-section together with the stream flow Q occurring at the time the cross-section was taken, an estimate of a for the particular location being considered may be obtained from Equation (1). Then, knowing the value of the constants a and b at each stream location studied, the mean velocity of flow, v, may be obtained at any flow, Q. For any given river stretch the time of passage is obtained by dividing the length of stretch by the mean velocity in the stretch.

The values for a and b used for each station are shown in Table C-1.

DEOXYGENATION RATES

The rate of biological oxidation or decay of BOD_5 generally follows a first order reaction whereby:

$$L_{(t)} = L_o 10^{-k_1 t} \tag{2}$$

in which $L_{(t)}$ is the amount of that originally present, L_o, remaining after t days. The percentage remaining is merely $10^{-k_1 t}$. An estimate of k_1 in a stream may be obtained by laboratory analysis of a series of portions of a given stream sample which are incubated for various periods of time. Such an analysis was carried out on about thirty stream samples during the fall as well as on each of the waste effluents. Incubation periods up to 18 days were used. The resulting values of k_1 for the stream samples are shown in Table C-1.

Several of the samples containing relatively fresh waste material, notably those from Worm Creek, were found to contain a fraction which decayed at a very fast rate while the remainder of the waste decayed at a slower, more usual rate. The k_1 rate for the fast component was found to average near 0.7 while the slow component k_1 value was usually near 0.2. In calculations of the rate of decay in streams only the slower k_1 value was used since after treatment and/or storage the fast-reacting component would no longer be present. Before using the k_1 values in Table C-1 in stream calculations they were corrected for the appropriate stream temperatures (10°C during the fall).

Table C-1

DEOXYGENATION AND STREAM VELOCITY CONSTANTS

		k_1 (20°C, days^{-1})			$V = aQ^b$	
Station	**No. of observations**	**Min.**	**Ave.**	**Max.**	**a**	**b**
W6.2	3	0.15	0.19	0.22	0.518	0.50
W2.0	3	0.15	0.16	0.17	0.269	0.50
W0.7	3	0.13	0.17	0.23	0.254	0.50
C13.6	1	0.18	0.18	0.18	0.112	0.33
C9.6	3	0.15	0.19	0.24	0.230	0.14
C6.4	3	0.19	0.25	0.31	0.274	0.14
C3.6	3	0.29	0.34	0.38	0.441	0.14
C0.8	3	0.13	0.20	0.28	0.118	0.14
B68.5	1	0.18	0.18	0.18	0.042	0.44
B63.0	2	0.13	0.18	0.22	0.042	0.44
B57.5	2	0.13	0.16	0.20	0.035	0.44